Intelligent Transportation Systems Strategic Deployment Plan for the Tucson Metropolitan Area

Pima Association of Governments

June 1996

Disclaimer

Prepared in cooperation with the U. S. Department of Transportation, Federal Highway Administration, and the Arizona Department of Transportation, Planning Division.

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INTELLIGENT TRANSPORTATION SYSTEMS (ITS) STRATEGIC DEPLOYMENT PLAN

PREFACE

In recent years, policy makers in major urban areas have more and more been coming to the conclusion that they “can’t build their way out” of the ever-increasing congestion that results from the demand for auto travel within metropolitan areas. Limited federal, state and local funds, combined with escalating construction and right-of-way costs, are prompting officials at all levels of government to seek ways to make existing transportation networks operate more efficiently. Compounding the problem is that operating and maintenance costs are consuming up to 70% of available transportation dollars. The greater Tucson metropolitan area (eastern Pima County) is no exception.

Intelligent Transportation Systems (ITS), formerly Intelligent Vehicle Highway Systems, offer public officials, in conjunction with the private sector, a unique and imaginative opportunity to respond to the growing mobility management problem by incorporating the most advanced (and emerging) technologies, many of which are an outgrowth of the nation’s defense industry.

This Strategic Deployment Plan for implementing ITS in the greater Tucson metropolitan area is comprehensive in scope in that it recognizes that the effective deployment of these technologies must be an ongoing process. In fact, its issuance coincides with the beginning of a two-year Action Planning and implementation period, within which not only are the recommended early deployment projects brought on line, but necessary administrative and financial processes also are institutionalized, thus assuring achievement of overall ITS objectives.

Certainly, ITS projects must legitimately compete with more traditional transportation projects for funding. However, the short and long range projects recommended within this Plan build upon existing ITS projects in the Tucson area. Moreover, they are regional in scope and consistent with the overall statewide ITS initiative. Thus, the benefits anticipated as a result of their implementation are compounded when compared to their cost.

As with analyses leading to the recommendations in the Plan, funding and implementation of the projects will be greatly enhanced by the truly cooperative and enthusiastic attitude of the contributing agencies and many public spirited citizens who contributed to the overall study.

Chapter 1. INTRODUCTION

1.1 What is an intelligent Transportation System?

Communities want their transportation facilities to provide reasonable access to activities for all people. They want transportation that is safe, efficient, comfortable and easily accessed.

An Intelligent Transportation System is based upon the premise that communities can better achieve these objectives if transportation facilities are developed and managed using a "systems engineering" approach.

A systems engineering approach means identifying each system component, specifying what each component does, describing how it relates to other system components, and relating all that to the ultimate objective of the whole system. A systems engineering approach means **an integrated system.**

An Intelligent Transportation System uses information to integrate all the components of a conventional transportation system (roads, transit, traffic control devices, etc.). ITS takes advantage of information flows among components to provide opportunities for feedback and performance evaluation. Information gathering and processing is integral to ITS and is achieved through the most recent technologies developed in the electronics, communications and information processing industries.

An Intelligent Transportation System describes a system that goes beyond the conventional. For example, it recognizes that **users** are system components. Naturally, this increases the system's complexity, but that increased complexity has big payoffs. Information flowing to the travelers can affect their travel decisions, thereby having the potential to improve overall system performance by better utilizing all system components. In other words, an Intelligent Transportation System allows existing facilities to be used more efficiently.

The concept of system "users" is, in fact, fundamental to Intelligent Transportation Systems. Users may include commuters, other travelers, commercial vehicle operators, emergency service providers, transportation managers and providers, and state and local governments. A user is anyone who benefits from ITS deployment.

The utility of ITS is exemplified by the services that ITS provides the users. Those services are termed "User Services." More than two dozen User Services have been defined as part of the national ITS program (see Appendix A for list of User Services).

The scope of an Intelligent Transportation System can best be understood by considering the following ITS functions:

- Surveillance
- Data Processing
- Control Strategies
- Traveler Interface

- Navigation and Guidance
- In-vehicle Sensing
- Communications

1.1 .1Functions

Information is the lifeblood of an Intelligent Transportation System because information is what integrates system components. Information, therefore, must be collected from the transportation system. Typically, the kinds of data collected include traffic volumes, locations of vehicles, whether equipment is working effectively, and the presence of a traffic incident that may be causing delay. The function of collecting data from a transportation system is called "Surveillance."

"Data Processing" is another function. It refers to the manipulating, configuring and formatting of transportation-related data. The information is manipulated differently depending on how it will be used, or what further function it will serve. It may be used for more efficient operation of traffic-control devices ("Control Strategies"). It may be packaged for access by users ('Traveler Interface"). It may provide a driver step-by-step instructions to a specified destination ("Navigation and Guidance")

"In-vehicle Sensing" is a function where technology is advancing at a rapid rate. It provides a range of sensing functions that are located within vehicles, including monitoring vehicle and driver performance and safety, determining vehicle position relative to the roadway and other vehicles, and improving vision in adverse conditions.

"Communications" is the function of transmitting information. Information needs to be transmitted from reception sites (a camera, for instance) to a management or data-processing center. Frequently the information is then reconfigured and redistributed to users of the transportation system. Every single User Service requires the communications function. That's because information, the integrating element of ITS, depends on the communications function for rapid and reliable transmission and subsequent dissemination.

Information must be reliable and up-to-date to be useful to users of the Intelligent Transportation System. Study organizers recognized this when they were developing the structure of this study, and gave the communications component of the study a special emphasis. The communications aspect of the study is called the TCOM 2000. The TCOM 2000 blueprints the communications network necessary to carry out ITS functions. For more details about the TCOM 2000, refer to Chapter 2, Background.

1.2 ITS Benefits

ITS promises to improve safety, make more effective use of available transportation capacity, increase operational efficiency, and enhance traveler mobility It also promises to improve comfort and convenience for the traveler, as well as have positive consequences for the environment.

How can ITS do all this? Information is the key.

ITS **improves the safety** of a transportation system by using information to integrate the roadway, the vehicle and driver. ITS subsystems can monitor the driver, the vehicle and the roadway and advise the driver about safety conditions and vehicle performance. This increased safety readiness helps drivers avoid collisions. ITS can monitor roadways for accidents and alert emergency-service providers. Prompt, appropriate medical treatment is effective in reducing the severity of injuries sustained and the number of fatalities. Rapid efforts to mitigate an incident will return the roadway to normal operation and thereby reduce the potential for other accidents on that roadway, as well as on roadways traffic has been diverted to. An example of how ITS might improve safety is described in the following scenario:

Scenario No. 1

You are driving down the Interstate destined for some large urban area that lies a couple of hours across the desert to the north. But before you even leave the city limits, an electronic sign advises you of imminent congestion due to a recent accident ahead. You proceed with greater vigilance and are able to respond quickly when you see the brake lights ahead... .

Information integrates users with the system. Improved access to up-to-the minute, or real-time, information encourages **more effective use of available transportation system capacity.** ITS provides travelers with the information necessary to avoid congested areas.

... You glance at your watch and are about to fake the next exit . . .

The rapid detection of and appropriate response to accidents and disabled vehicles favorably impacts the **operational efficiency** of the transportation system by reducing disruptions due to incidents. Through ITS, accidents and disabled vehicles can be cleared in up to half the normal time.

., but you see the wrecker is already removing the debris.

ITS recognizes that information flowing to travelers can affect their travel decisions. **Traveler mobility is enhanced** through access to current, up-to-date information before a trip begins or while a traveler is en route.

Scenario No. 2

> *You're going* across *town to do some shopping. First, you check your television. Check your television? Why? Because the public-access cable TV station provides information about roadway congestion levels, that's why. A display on the screen shows a map of major roads, and uses various colors to indicate whether there are any major tie ups. You decide which route offers* the *quickest and smoothest trip, so you grab your sunglasses and go. ...*

ITS further **enhances operational efficiency** by using real-time data to better operate traffic-control devices.

> *... You are on your way, behind the wheel. You have the windows rolled up,* you've *got the radio on,* and most *of the* signals *are green! You are floating down the road in a platoon of cars, buses and trucks, and the traffic signals turn green as if they literally see you coming! Who* are *you, President of the United States? Not* really. *With high-tech vehicle detection and new timing algorithms, traffic-signal systems are now better able to* respond *to the real-time demands of the arterial system.*

Through increased access to information, the **comfort and convenience** of the surface transportation system is also increased. ITS can provide travelers with user-friendly information about transit schedules and fares. Rapid processing of information can provide enhanced and more efficient door-to-door transit service and facilitate ride sharing. Automatic Vehicle Location (AVL) automatically tracks the location of transit vehicles; this information helps schedulers make sure buses are on time, and can let riders know when their connection will arrive. Electronic Payment Systems make paying fares more convenient because transit riders don't have to carry a pocket full of change. Electronic Payment Systems work because the necessary billing information is automatically read from a "smart card" with a magnetic strip.

Scenario No. 3

> *You've started taking the bus to work to save money and spare the air. It was* easy *to figure out which bus to take by accessing a traveler information center using your persona/ computer at home. You found out that your commute requires you to make a transfer at the downtown transit center. A video terminal there tells you that the bus is almost in. You reach into your pocket and have your debit card ready by the time the bus pulls into the*

station. You board quickly, and within minutes, you are on your way. . . .

ITS can **enhance fleet performance.** Information about fleet performance and condition can be gathered through automatic data collection, allowing improved management and planning for commercial and transit fleets.

. . . Your presence on the bus was automatically counted when you paid your fare. A ridership report automatically informs planners that your route is one of the busiest. Service soon will be expanded, making your trip even easier.

Increased efficiency and access to information **improves environmental quality.** Fewer idling cars and trucks translates into better air quality. Because information about routes, fares and connections is easy to access and understand, transit usage is more appealing to potential first-time riders. Some ITS technologies will allow transportation policy makers and planners to implement measures that influence a traveler's choice of travel mode and travel time. These types of opportunities can lead to improvements in air quality.

1.3 National Context

The conventional solution to the demand for more mobility has been to build more roadways and expand existing ones. While some facilities simply must be expanded, building new physical capacity, however, is not always the optimal solution.

For one thing, construction costs are increasing. The costs associated with acquiring right-of-way are increasing, and frequently, acquisition of new right-of-way disrupts businesses and neighborhoods and has detrimental impacts on environmentally sensitive areas. And further, there is growing recognition that the congestion relief realized through the addition of new physical capacity may be short-lived.

Yet the need for mobility is even more pronounced today than in past. The economy has seen a shift from heavy industry to lighter manufacturing and service industries, which need quick, reliable access to markets to maintain competitiveness. Even in manufacturing, just-in-time parts delivery is common, as manufacturers do not maintain large inventories. Transportation is more important than ever before.

At the same time, the defense industry is developing new markets for the technological advances that characterized it during the Cold War. In addition, competition within the telecommunications industry has provoked a wide array of communications services. The recent federal deregulation of the industry will certainly inspire further advancements, therefore providing opportunities for developing comprehensive information networks.

1.3.1 ISTEA Legislation

The national context described above gave impetus to the ITS (formerly IVHS) Act contained within the federal Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991.

ISTEA redirects national surface transportation priorities. It calls for improved planning and management of the nation's transportation program and more efficient and environmentally sensitive use of multimodal transportation facilities.

ISTEA goals include:

- enhancing the capacity, efficiency and safety of the highway system;
- enhancing efforts to attain air-quality goals established by the Clean Air Act;
- reducing societal, economic, and environmental costs associated with traffic congestion; and
- development of a "seamless" transportation system, which is characterized by the streamlined transfer of goods and people between modes of travel.

ITS can help meet those goals.

1.3.2 The National ITS Program

The ITS Act established a national ITS program to promote implementation of ITS systems. The national ITS program has provisions for research and development, and operational tests, including a prototype automated highway.

ISTEA requires that the U.S. DOT prepare a strategic plan to guide the development and implementation of ITS in the United States. The U.S. DOT ITS Strategic Plan (December 1992) set forth goals, milestones and objectives of the national ITS program and established the U.S.DOT's role in creating an environment conducive to ITS development and deployment. This plan was followed by the National ITS Program Plan (March 1995), which defined the needs and perspectives of the broader ITS community.

The national ITS program is focused on the development and deployment of a collection of interrelated User Services. As mentioned earlier, User Services explicitly define the utility of ITS in terms of services that ITS can provide. Twenty-nine User Services have been defined as part of the national program planning process.

ISTEA also requires establishment and maintenance of a repository for technical and safety data related to ITS projects, and allows this responsibility to be delegated to an advisory committee. Consistent with the act's recommendation for maximizing the involvement of the private sector, this responsibility has been delegated to the Intelligent Transportation Society of America (ITS America).

ITS America is chartered as a Federal Advisory Committee to advise the U.S. DOT on the ITS program. In addition to the clearinghouse responsibility, ITS America advised the U.S. DOT on the development of the ITS Strategic Plan and the National ITS Program. ITS America takes an active role in the development of a national ITS architecture and setting national ITS standards. ITS America is supported by state chapters, such as ITS Arizona, which is an active ITS proponent within the state.

The ITS legislation focuses mainly on research and development and on operational testing. The Congress recognized that a federal funding commitment to ITS deployment is necessary to maintain momentum of the national ITS program, so that U.S. industries can compete successfully in the emerging international ITS marketplace. Operation Timesaver addresses this need.

1.3.3 Operation Timesaver

On Jan. 10, 1996, Secretary of Transportation Frederico Pena announced a national goal to build an Intelligent Transportation System infrastructure across the United States. He called for the 75 largest metropolitan areas in the United States to be outfitted with the transportation infrastructure to support ITS within 10 years. In describing this initiative, he coined the term "Intelligent Transportation Infrastructure" or ITI.

The ITI consists of ITS features considered essential for maximizing the benefit of the ITS User Services. While these features require the public sector to take the initial lead, it is believed in fact essential that their deployment will encourage the private sector to become deeply involved in the deployment of additional ITS products and services. ITI is built around:

- *Traffic Signal Control Systems* - systems that sense how heavy traffic is and adjust automatically, according to traffic volume.
- *Freeway Management Systems* - systems that provide the capability to monitor freeway conditions, identify incidents, and implement traffic-control strategies.
- *Transit Management Systems* - for improving fleet management and transit service.
- *Incident Management Programs* - for quickly identifying and removing incidents that occur on freeways and arterials.
- *Electronic Fare Payment Systems* - systems that make paying fares and tolls more convenient.
- *Multimodal Traveler Information Systems* - a repository of current, comprehensive and accurate roadway and transit performance data made accessible to users so that they can make informed travel decisions.
- *Railroad Grade Crossing Safety improvements*

Key to ITS deployment is that each geographic area design its own system, tailored to its specific needs, while at the same time conforming to the national ITS architecture. How ITS will address specific regional needs will be decided locally.

1.3.4 Early Deployment Planning

Designing an Intelligent Transportation System to suit an area's unique needs is what the early deployment planning process is all about.

Rather than throwing technologies at the transportation system and seeing if they stick, the Federal Highway Administration applies the systems engineering approach to ITS planning. The Strategic Deployment Plan for Eastern Pima County followed the Federal Highway Administration's ITS planning process.

1.3.5 ITS Planning Process

Consistent with ISTEA legislation, public involvement is integral to the ITS planning process. The community is asked: What are your transportation needs? Responses are collated and assessed for their compatibility with the above-mentioned ITS User Services.

Analysis of results stemming from the public participation effort and the mapping of needs to User Services is documented in a User Services Plan. The User Services Plan ranks User Services and prioritizes them for deployment.

Each of the ranked User Services is analyzed to identify what functions, or actions, are required to provide the User Service. This task underscores the rationale for giving special emphasis to communications in the development of the Tucson Advanced Transportation Technologies Implementation (TATTIP) Strategic Deployment Plan. As functions are identified for each User Service, it becomes clear that the communications function is common to all of them.

Identifying functions (see Section 1.1 .1) and the organizations involved in the carrying out of functions is a step toward developing an ITS architecture. Functions are then analyzed for candidate technologies and a blueprint for an ITS system architecture emerges.

More detail is given to this process, in the description of the Strategic Deployment Plan process in Chapter 2 of this document.

1.4 What You Can Expect from the Rest of the Document

The preceding discussion has provided a basis for understanding ITS and why a national ITS program exists for ITS promotion and implementation. The following chapters describe how ITS will be implemented in the PAG region.

Chapter 2 provides an overview of study activities. By following the evolution of the Strategic Deployment Plan, a fuller understanding can be gained of the FHWA's ITS planning process. In this Chapter, the unique two-pronged project structure is described. Important existing and committed ITS projects for the Tucson metropolitan area and their linkages to regional and statewide ITS enterprises are explained, as well.

By its very nature, as a system of interrelated components, ITS transcends local jurisdictional borders. **Chapter 3 discusses the** organizational structures surrounding the Plan development, including provisions made for oversight and public involvement. An organizational structure to maintain enthusiasm for ITS in the two years that immediately follow publication of this Plan is recommended. Also in this chapter, a flow chart tracks the development of a typical project, from its conception within the Strategic Deployment Plan document through its implementation.

Chapter 4, the core of this document, highlights ITS projects recommended for the PAG region. Projects for the short term (early deployment) are described in sufficient detail that project design can commence as soon as funding is available and participant consensus is obtained. Projects for the long term are described in less detail. A description of non-ITS activities that enhance ITS projects also are included in this chapter.

No ITS project can become a reality without adequate funding. **Chapter** 5 addresses funding issues, identifies potential funding sources, and discusses potential availability of funds.

There is a continuing need to carry out activities described in this document, and to improve and update the Strategic Deployment Plan over time. **Chapter** 6 defines a two-year Action Planning period and discusses projects, funding and organizational issues for that period.

Chapter 7 summarizes the document and the issues and complexities unique to Intelligent Transportation Systems.

Chapter 2. BACKGROUND

2.1 Project History

ITS technology is moving out of the laboratory and into the nation's communities, through the efforts of the Federal Highway Administration and ITS early deployment grants to most of the 75 largest urban areas in the United States. Tucson's early deployment project, the Tucson Advanced Transportation Technologies Implementation Plan (TATTIP) is predicated on capitalizing upon and enhancing the existing ITS investment in the metropolitan area, is responsive to the expressed needs of the community, and is compatible with ITS activities ongoing throughout the State. The half-million-dollar TATTIP began in July 1994 and has been administered by the Pima Association of Governments Transportation Planning Division (PAGTPD).

As already mentioned, the Federal Highway Administration applies the systems engineering approach to ITS planning. The Scope of Work for the TATTIP follows the FHWA ITS planning process, which is shown in Fig 2.1.

The following discussion describes how the TATTIP followed the federal ITS planning process. The discussion begins with the task of developing of the basic structure for supporting the enterprise.

2.1 .l Establish Institutional Framework and Build Coalition

Drawing upon the champions of the 1993 PAG Freeway Management System design study, a Study Advisory Committee (SAC) for the TATTIP was formed. The SAC is a policy-making body and provides project oversight and study guidance. Table 2.1 lists the SAC members and the agency each represents.

Table 2.1 TATTIP Study Advisory Committee Members

SAC MEMBER	AGENCY
Jim Glock	City of Tucson, Transportation Department
Alan Hansen	FHWA
Sarath Joshua	ADOT, Transportation Research Center
Richard Nassi	City of Tucson, Traffic Engineering
Kenneth Shackman	Pima County, Traffic Engineering
Dennis Sheppard	University of Arizona, SIE Dept.
John Semmens	ADOT, Transportation Research Center
Tom Swanson	Pima Association of Governments

FHWA ITS Planning Process

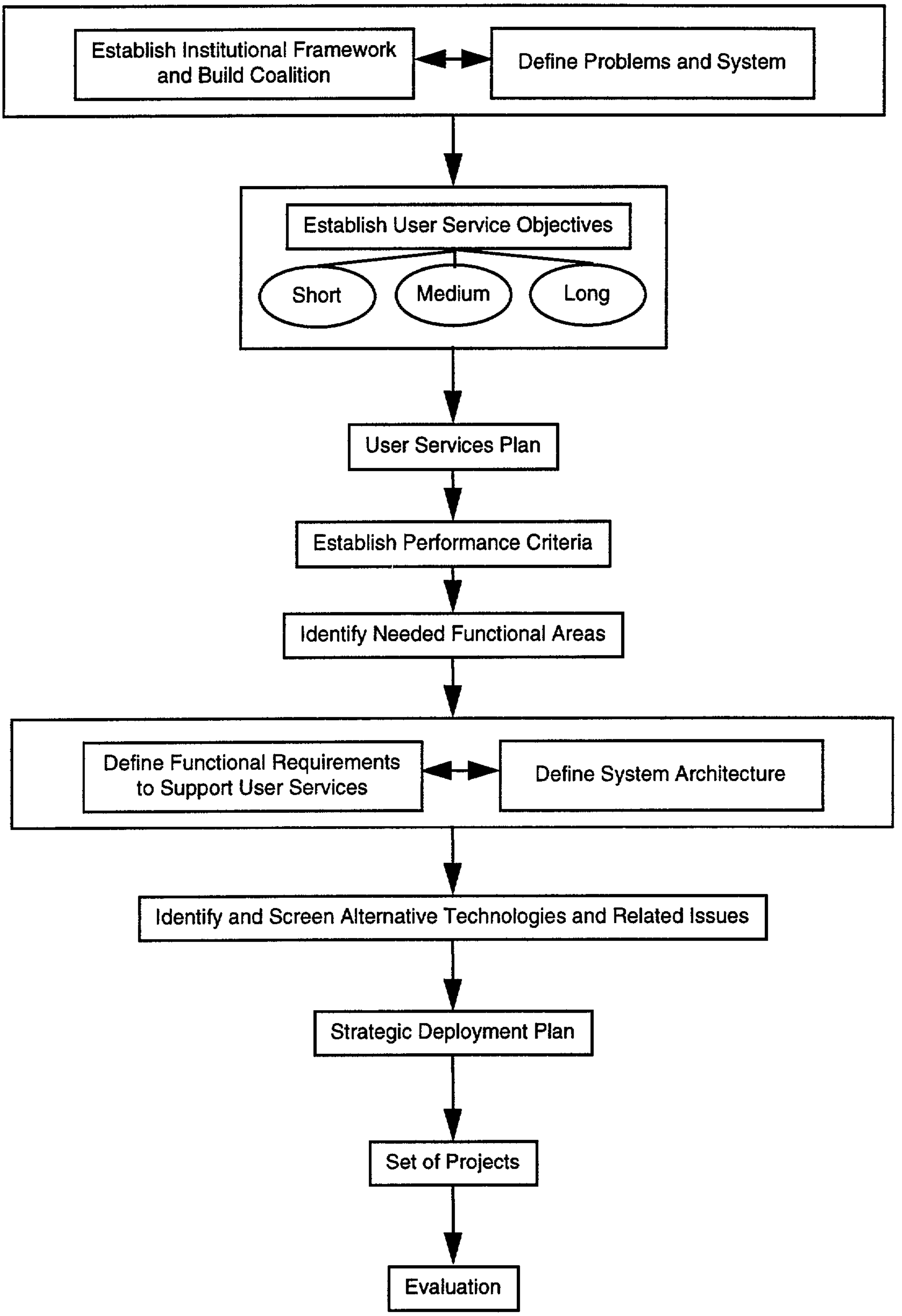


Fig. 2.1 FHWA ITS Planning Process

The SAC readily recognized that communications is a key function within an Intelligent Transportation System. To attract the level of communications expertise that the SAC felt was required, all tasks directly relevant to developing a communications network for ITS were segregated. The resulting array of activities constitutes the communications component of the study, and is designated TCOM 2000. A Request For Proposals (RFP) was advertised for the TCOM 2000 in November 1994.

Catalina Engineering, Inc., of Tucson, Arizona, was selected in January 1995 to perform the work associated with the TCOM 2000. A Technical Advisory Committee (TAC) was assembled from communications experts both in the public and private sectors to provide technical advice to the consultant. (A list of TAC members is included in Appendix B.)

The SAC believed strongly that overall quality control of the study could best be assured by having portions of the project carried out in-house. Tasks within the TATTIP scope of work that would best be performed by TATTIP staff were identified.

Following that, a second RFP was prepared addressing the remaining ITS planning tasks. Identifying appropriate User Services and technological options for providing those services are important tasks within the second component, hence that component of the overall study is referred to as the "User Services/Options Study."

To meet perceived technical writing and coordination needs, an ITS Coordinator/Technical Writer was retained by PAG in March 1995. Subsequently, the second contract for the "User Services/Options Study" was also awarded to Catalina Engineering in April 1995. A Citizens Advisory Committee (CAC) was assembled, representing a broad sector of the community, to provide input on the Plan as it evolved. (A list CAC members also is included in Appendix B.)

In summary, The TATTIP adapted the FHWA ITS planning process, delegating responsibility for completion of tasks among the three components: that which is accomplished by TATTIP staff, that which is accomplished as part of the User Services/Options Study, and that which is accomplished as part of the TCOM 2000. This construct is illustrated in Fig. 2.2 and provides the basis for the discussion that follows.

As shown in Fig. 2.2 on page 15, development of the TCOM 2000 component mirrors the FHWA ITS planning process. In the following discussion of the TATTIP, TCOM 2000 activities reflective of the FHWA ITS planning process are identified with the following logo.

TCOM 2000

2.1.2 Define Transportation Problems and System

This task is twofold: acquiring input from stakeholders and the public, and reviewing existing documents and projects to assess the extent to which technology is currently being utilized for transportation purposes in Eastern Pima County.

Input from stakeholders and the general public was obtained from a broad range of transportation users, including sectors with specific needs, such as commercial transportation services, trucking, and emergency services. User input was acquired through **focus groups** and via a statistically reliable **telephone survey** of registered voters in Pima County.

Existing transportation plans, projects and studies shed considerable light on transportation needs. Together, they describe goals and objectives of the area transportation-planning agencies and establish a base line from which an ITS infrastructure can emerge.

The following discussion elaborates on the two information-gathering techniques, and discusses the existing transportation system.

Focus Groups

A focus group is a meeting of a small number of individuals with similar interests, convened to discuss and offer opinions on a single topic. It is facilitated by a leader who explores attitudes in depth through follow-up questions.

Eight focus areas were identified: Citizens Advisory Committee; Emergency Service Providers; Commercial Vehicle Operations (trucking): Major Employers/Tourism; Commercial Vehicle Operations (non-trucking); General public: Commercial Vehicle Drivers; and Transportation Agencies.

Focus group members voted for what they perceived as the three most significant transportation-related problems/needs. Members were encouraged to focus on issues specific to the interests of the group they represent.

For a list of focus groups, members, and results, refer to the User Services/Options Technical Memorandum No. 3, “Acquire Public and Stakeholder Input.”

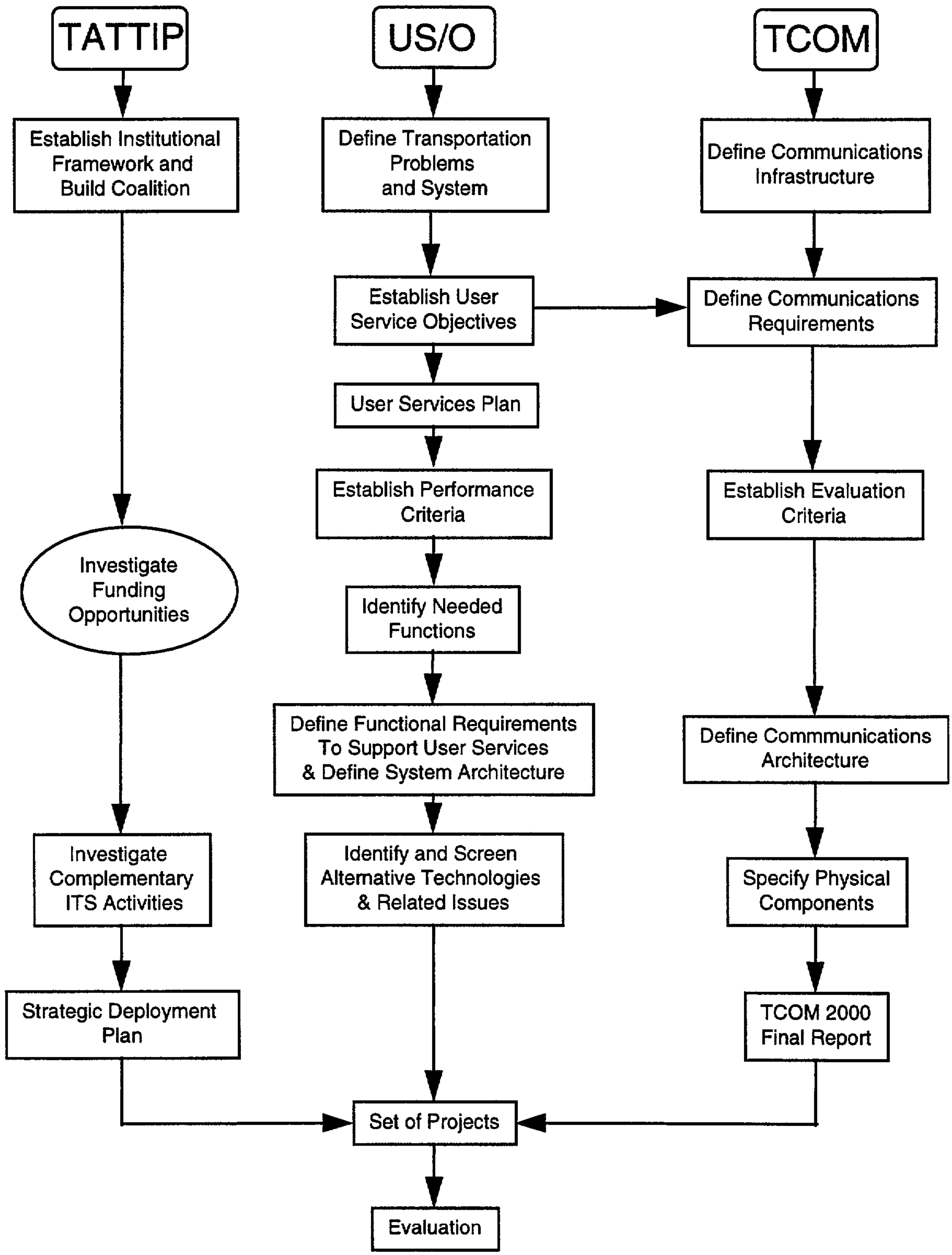
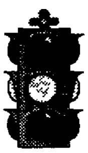


Fig. 2.2 TATTIP Planning Process

Telephone Survey

To gather reliable information on the traveling public's general perceptions of the transportation system in Pima County and on potential early applications of ITS technologies, a statistically significant telephone survey of 406 registered Pima County voters was conducted between Aug. 17 and Aug. 28, 1995. The margin of error for this study was 4.9 percent at the 95 percent level of confidence, meaning that in 95 out of 100 cases, the responses indicated will be within +/-4.9 percent of the responses if the entire universe (all registered voters in Pima County) were interviewed. The survey, developed collaboratively by Catalina Engineering, project subconsultants and PAGTPD staff, was comprised of 38 questions. It was structured so as to help establish the need for an improved transportation system from the public's perspective, as well as the potential level of acceptance for the implementation of ITS technologies to address existing needs. Again, refer to the User Services/Options Technical Memorandum No. 3 "Acquire Public and Stakeholder Input."



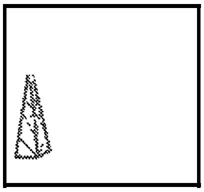
The Transportation System

Selected roadway and infrastructure conditions were reviewed, as were projects, plans and intergovernmental agreements pertinent to ITS in eastern Pima County. This type of information helps define the direction in which PAG transportation agencies are headed with respect to the application of advanced technologies and travel demand management.

During the review process, particular attention was placed on identifying:

- transportation problems, needs and objectives that have been previously recognized;
- current policies and initiatives regarding transportation in the region:
- existing and planned infrastructure that will support the implementation of **ITS** applications;
- existing and planned ITS applications; and
- existing and developing organizational structures and institutional arrangements relative to the operation and maintenance of the transportation system.

Refer to Technical Memorandum No. 2 for User Services/Options Task B "Assess Regional ITS Resources and Operations" for more details about specific transportation programs and projects. Refer to the User Services/Options Technical Memorandum No. 4 "Document User Services Plan" for a description of regional transportation conditions and resources.



TCOM 2000 - Define Communications Infrastructure

Just as the FHWA ITS Planning process begins with an assessment of the existing system, problems and needs, the TCOM 2000 began with an assessment of the existing communications infrastructure. This process involved surveying public agencies and private communications providers, as well as conducting personal interviews. The TCOM 2000 Technical Advisory Committee proved to be an invaluable resource. The output of this task is TCOM 2000 Technical Memorandum No. 1, " Define Infrastructure."

As indicated in Technical Memorandum No. 1, the existing, committed and planned broad-band communications facilities in Pima County are primarily fiber-optic and microwave facilities. Conduit that may be used for installation of future fiber-optic facilities was also identified. In addition, agency communications protocols and interagency linkages were identified. Technical Memorandum No. 1 features: a map showing the locations of existing and proposed fiber optic facilities: a tabular summary of the communications facilities by agency or service provider; and a description of local and wide-area communications facilities and service listed by agency or provider.

2.1.3 Establish User Service Objectives

All the input from the public-involvement effort, including the Citizens Advisory Committee, helped determine the desirable and practical timeframes for implementation of the User Services. The following table shows the top-ranked User Services and the time-frames considered suitable **for their implementation. Short term refers to** 19951999, **medium term to 2000-2005, and long** term 2006 and beyond.

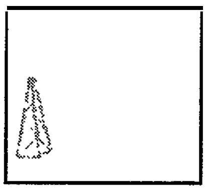
As shown in Table 2.2 on page 18, Pre-Trip Traveler Information, Traffic Control, Incident Management, En-Route Travel Information, Public Transportation Management, Ride-Matching And Reservation, and Commercial Vehicle Electronic Clearance are identified for short-term deployment. These User Services were identified for short-term deployment primarily because all of them currently exist or are under development within eastern Pima County. It is efficient and practical from both a funding and technical perspective to begin building an ITS infrastructure based upon existing ITS projects. Initial efforts and funding should be directed toward regional deployment of these User Services.

Table 2.2 Time Frames for Implementation of User Services

TIME FRAME	USER SERVICE
Short Term	Pre-Trip Traveler Information
	Traffic Control
	Incident Management
	En-Route Travel Information
	Ride-Matching And Reservation
	Public Transportation Management
	Commercial Vehicle Electronic Clearance
Medium Term	Travel Demand Management & Operations
	Personalized Public Transit
Long Term	Route Guidance

The two User Services recommended for medium-term deployment are Travel Demand Management & Operations and Personalized Public Transit. While the technology necessary to implement these User Services is available, the need for these services is not considered urgent. Deployment of these services is suggested after the year 2000.

Route Guidance is the only User Service identified for long-term deployment. While the technology for Route Guidance is currently being developed, it is still several years away from being viable within large metropolitan areas. Furthermore, this User Service is considered a “convenience service” and, accordingly, its deployment is not considered urgent. See User Services/Options Technical Memorandum No. 3 “User Services Plan”.



TCOM 2000 - Define Communications Requirements

As shown in Fig. 2.2, the recommended User Services are input into the process of defining communications requirements. Another goal of this communications network is to support common organizational internetwork services, such as e-mail, remote system log-on and file-transfer capabilities, video conferencing, and access to high-resolution graphics and maps.

The products resulting from the communications analysis include interconnect diagrams and service tables and an assessment of agency support systems. Together these products were used to define the network communications requirements, which were input to the communications network development process.

Current organizational and institutional issues that impact access to existing databases include security, ownership, liability and hardware/software requirements. A discussion of each of these issues, including examples of their current impacts on data access and exchange is provided in TCOM 2000 Technical Memorandum No. 3, as well.

2.1.4 User Services Plan

The User Services Plan, (User Services/Options Technical Memorandum No. 3) focuses on the selected User Services and their time frames for deployment; it also summarizes the User Services' relationship to ITS infrastructure elements prescribed by the U.S. DOT, otherwise known as Intelligent Transportation Infrastructure (ITI). This Plan should be a significant reference for future ITS related projects within eastern Pima County.

The User Services Plan also summarizes the existing transportation system and the various goals and service objectives of the transportation planning agencies in the PAG region

2.1.5 Establish Performance Criteria

Consistent with the ITS planning process, performance criteria were established for the top-ranked User Services. The criteria and performance standards provide both qualitative and quantitative measures of effectiveness of project implementation. The recommended performance criteria were arrived at by a systematic review of user service objectives, established regional **ITS** goals and recognized benefits of ITS. The Citizens Advisory Committee provided important input to Catalina Engineering in the development of these criteria. They are documented in User Services/Options Technical Memorandum No. 5 “Establish Performance Criteria.”

Performance measures are especially important for ITS for two reasons: 1) local agencies want to be able to measure the performance of the system following their investment in new technology; and 2), ITS being information-based, is readily adapted for the collection of data. Future initiatives for deployment of ITS will put strong emphasis on collecting data for performance evaluation.

TCOM 2000 - Establish Evaluation Criteria

The following performance criteria were adapted for the communications system that supports ITS:

- **application performance** - ability to deliver a certain level of quality (e.g., response time);
- **security & privacy** - e.g., access control, encryption;
- **reliability & availability** - performance among component failures;
- **operations & maintenance** - ability to monitor and control network elements;
- **standards & conformance** - how well network conforms to standards;
- **scalability & flexibility** - ability to meet unforeseen requirements and technologies; and
- **multiple sourcing** - how well the architecture is supported by multiple vendors.

2.1.6 Identify Needed Functions

Then the question was asked, "What functions need to be performed to provide the identified User Services?" Each User Service is achieved through the application of several technologies that perform one or more of system functions. Chapter 1.1.1 broadly described basic ITS functions. The seven basic functions summarized below characterize existing and emerging technologies.

Table 2.3 Basic ITS Functions

Surveillance	*Collection of speed, volume, densities, travel time, queue length, position, classification, weather, hazardous material (etc.) information.*
Data Processing	*Management integration and quality control of all data and algorithms pertaining to ITS.*
Control Strategies	*Strategies implemented by systems to help regulate traffic flow and ensure traveler safety.*
Traveler Interface	*Means by which a user interacts with information devices.*
Navigation/Guidance	*Systems to assist travelers in route planning, position identification and route following.*
In-vehicle Sensors	*Monitoring of vehicles, driver and external driving environment that pertains to vehicle operations.*
Communications	*Transmission of voice, data and video information among vehicles, and system infrastructure.*

2.1.7 Define Functional Requirements To Support User Services & Define System Architecture

The objective of this task is to define the above functions with greater specificity, including major information flows and databases, and other requirements necessary to support User Services. Functional requirements can be mapped into a logical ITS system architecture, which shows the relationships among the various ITS functions (which are defined to a high level of detail) and their clustering into four major User Service groupings: Traffic Management, Emergency Management, Public Transit Management, and Traveler Information Management. Within each User Service grouping, the individual User Services have relatively high connectively compared to the connectivity among the groupings themselves. These User Service groupings are the basis for management center subsystems that are identified in the physical architecture development process. The information flow among functions and management centers (identified, at this point, in concept, but not as physical entities) relates to the communications architecture.

A physical ITS system architecture is created when the technology to carry out the ITS function is identified. In addition, the physical ITS system architecture identifies the physical subsystems, and interconnections between subsystems needed to implement the processes and support the data flows. In other words, the physical ITS system architecture identifies where and how the functions are performed.

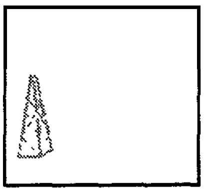
In the process of defining a physical ITS system architecture, existing and planned ITS **activities in** the region are acknowledged. The existing architecture consists of area traffic agencies managing their own field controllers environment with some exceptions. No formal concept of a Regional Traveler Information System is currently deployed, although the City of Tucson is developing certain traveler information components. Commercial television and radio stations provide traveler advisory information, supported by private sources of information. Existing and planned ITS activities, such as the City of Tucson Traffic Management Center and the Sun Tran Transit Management Center, serve as a foundation for the physical architecture. Other physical subsystems are identified, including a roadside subsystem, traveler information and three vehicle subsystems: personal vehicle, commercial vehicle and emergency vehicle.

In a process called “physical partitioning,” the functional requirements are allocated to physical subsystems. This process resulted in five candidate physical ITS system architecture alternatives. For a description of the five candidate architectures, refer to User Services/Options Technical Memorandum No. 6.

The five candidates were evaluated according to criteria adapted from the National ITS Architecture Development program. These criteria address the physical architecture itself, but also evaluate actual deployment, the technologies used in that deployment, and the resulting operations, risks, costs and other issues. The architectures were assessed in an absolute sense, i.e., the architectures were not rated against each other. For a description of the evaluation criteria and evaluation, refer to User Services/Options Technical Memorandum No. 6.

A "peer-to-peer architecture with permissive control" is recommended to support ITS in the region. This architecture is becoming the standard architecture for metropolitan areas, large and small. It describes an architecture in which all the management centers (traffic, transit, incident management) within the Metropolitan Tucson Area are interconnected and capable of full sharing of data and video (peer-to-peer). It allows one agency, if permission is granted, to access another agency's system for the purposes of temporarily obtaining control of certain system components, e.g., cameras, changeable message signs, signal controllers (permissive control). With permissive control, for example, the City of Tucson could use a camera installed on the I-10 (ADOT) to check on the status of traffic on the adjacent city arterial system. Or Sun Tran could, with permission from the City Traffic Management Center, use a City of Tucson camera to view the status of a bus or transit route. Conversely, ADOT could access the city's changeable message signs during a weekend or at night to warn motorists of problems on the freeway.

A "peer-to-peer with permissive control" architecture provides the highest level of operating flexibility, particularly during off-hours and on weekends when staffing of the management center is often significantly reduced. Refer to US/O Technical Memorandum No. 6 for further details.



TCOM 2000 - Define Communications Architecture

Based on the communications requirements of the recommended system architecture (peer-to-peer with permissive control), the TCOM 2000 study recommends a communications architecture that can evolve to meet the needs of ITS as it is deployed in the PAG region. The ultimate communications architecture reflects the state-of-the-art in communications technology, and is the architecture which ranked highest according to the selected evaluation criteria. The ultimate communications architecture, however, is costly and would provide bandwidth capacity in excess of what is required for transportation purposes for the near term. TCOM 2000 recommends that in the initial architecture deployment, opportunities be taken to implement elements of the ultimate architecture as needs warrant.

The recommended initial communications deployment is arranged so that there are point-to-point connections among agencies, with redundant links along the most critical paths. Time Division Multiplexed (TDM) communications protocol is recommended for initial deployment because it is a mature, cost-effective technology. The City and County already operate TDM-based networks, therefore the recommended initial architecture can be deployed as an expansion of the existing network.

Existing City/County fiber is used to establish point-to-point connections among the Tucson Fire Dept., Tucson Police Dept., and the Public Works Building. The TCOM 2000 recommends that a fiber-optic link be installed between the Price Service Center and the Public Works Building, and the ADOT District TOC and the Public Works building due to the criticalness and high bandwidth requirements of these links.

Microwave is recommended for the backbone link between UA and Public Works because of their proximity and the high bandwidth requirements of this link. The other backbone links (other management centers, if any, or the ADOT TOC in Phoenix) could be either microwave or leased service.

Ultimately, the communications architecture should be built to assume a ring configuration. This “ring topology” provides maximum redundant links for reliability. Multiple interconnected rings can be used to build an even more robust network.

In addition, the ultimate communications architecture will utilize a combination of SONET (Synchronous Optical Network) and ATM (Asynchronous Transfer Mode) communications technologies. SONET allows data that arrives at slower rate to be accessible at a higher rate, so “multiplexing and demultiplexing” processes are eliminated. In addition, SONET reserves bandwidth for network management services (like detecting failures in the links).

ATM utilizes bandwidth more efficiently than the tried-and-true TDM technology, and with ATM, it is easier to scale up to more complex network designs. Through combining ATM and SONET, you get the advantages of the robust SONET ring along with the dynamic bandwith and integrated access of the ATM transport. Both SONET and ATM are advanced technologies, and it is anticipated that when communications requirements in the region warrant the SONET/ATM solution, the costs associated with it will be lower than they are today.

The TCOM 2000 recommends that the highest bandwidth links (between TMCs) be the first to be replaced by SONET/ATM solutions. Meanwhile, TDM equipment can be redeployed to lower-demand links elsewhere on the network. The evolution will start at the center of the backbone network and work its way to the outer perimeters.

More details about the candidate communications architectures and evaluations are available in TCOM Technical Memorandum No. 3.

2.1.8 Identify and Screen Alternative Technologies & Related Issues

The purpose of this task is to identify for the overall Intelligent Transportation System a range of desirable technologies to carry out previously identified functions, and which can be supported by the ITS system architecture.

Technology assessment considers technical issues, like: performance, growth capability, “open” architecture, compliance with standards, compatibility with existing and currently planned systems, reliability, and environmental impacts. It also considers "related issues," such as: life-cycle cost/benefit analysis, maintenance and operations requirements and cost, procurement alternatives, personnel skills and work-load impact.

A significant level of coordination with the TCOM 2000 project was necessary. The communications requirements of ITS technical options often represent the major portion of life-cycle costs and maintenance requirements of an Intelligent Transportation System. In addition, how well a particular technology works with other system components is generally defined by the ITS communications needs. As such, the identification of ITS technological options and specification communications equipment were significantly intertwined.

An in-depth evaluation of existing technology and recommendations for ITS technologies are included in the User Services/Options Technical Memorandum No. 6.

TCOM 2000 - Specify Physical Components

The physical components of the communications architecture includes both computer and computer peripheral equipment required to perform the data processing. The security and encryption of data, communications protocols, network switching and video transmission were addressed as part of this task.

Identification of TCOM 2000 network components needed to implement the recommended ITS communication architecture is included in TCOM 2000 Technical Memorandum No. 3.

2.1.9 Strategic Deployment Plan

As illustrated in Fig. 2.2 , the development, publication and distribution of the Strategic Deployment Plan falls under the purview of the TATTIP staff. The process began in December 1995 and continued through May 1996. In preparation of the plan, TATTIP staff relied heavily on information contained in Technical Memoranda prepared by Catalina Engineering.

TCOM 2000 Final Report

The final report for the TCOM 2000 project provides documentation of each of the activities undertaken to develop a transportation communications architecture for the PAG region. This document defines the organizational components of the TCOM 2000, as well as including draft Intergovernmental Agreements and procedures for the inclusion of outside agencies and organizations, The document offers a recommended network deployment plan; the goal for this document is that it become a “working manual” for ongoing implementation of the system.

2.1 .10 Set of Projects

The Strategic Deployment Plan contains a set of specific ITS projects for implementation in Eastern Pima County. Projects are identified for both short- and long-term planning horizons, and a brief rationale for each project is included. The projects identified for short term implementation are described and developed in sufficient detail such that they can go directly to the design process.

2.1 11 Evaluation

This step will follow each project’s construction. Projects are to be assessed according to the performance criteria referred to earlier.

2.2 Existing and Committed Projects

Due to the foresight of its transportation agencies, the PAG region already has made a significant investment in ITS infrastructure. ITS projects are continually developing, and any description of the system can only be regarded as a snapshot in time. More extensive documentation can be found in the “Inventory of ITS resources,” which is User Services/Options Technical Memorandum No. 2.

2.2.1 City of Tucson Traffic Management System

The City of Tucson Traffic Management System monitors and controls some 350 traffic signals from a traffic management center located in the County-City Public Works Building. The system has the potential to control more than 600 signals. The system covers all City signalized intersections, as well as about 40 Pima County and ADOT signals.

Arterial traffic monitoring is currently performed using loop detectors embedded in the roadway surface. Due to ongoing detection performance problems, however, the City is investigating other monitoring technologies, such as video-detection systems. The City has reached an agreement with ADOT to utilize video detection at the I-10 interchanges as the frontage roads are rebuilt. Communications for the signal system are currently provided by a combination of leased telephone lines and twisted-pair cable owned by the City.

2.2.2 Tucson Travel Vision

Tucson Travel Vision is a prototype Traveler Information System being developed from the City's Traffic Management System. The information will be conveyed in the form of an electronic map.

Ultimately, the system will utilize the monitoring, communications and data processing capabilities of the existing traffic-signal management system to monitor traffic conditions along major arterials. The map will display the Tucson arterial system with a color code indicating congestion levels. Blue translates into "You'll get to work on time." Yellow means, "Better leave a little early." Magenta means heavy delay is possible, and flashing red means an accident is probably seriously restricting traffic.

The electronic map will be made available on the local public-access cable-TV channel between 7 and 9 a.m. and 4 and 6 p.m. Upon demonstrated success, the system will be expanded in both coverage and service. There are plans to make additional information available through the Internet and to link the Tucson Travel Vision and transit databases.

2.2.3 Sun Tran AVL

The City of Tucson is installing an Automatic Vehicle Location (AVL) system on the existing Sun Tran transit fleet. The AVL system will use Global Positioning Systems (GPS), a technology that relies on satellite communications. The AVL system eventually will automatically compare a bus' actual location to where it is supposed to be, thus providing automated schedule comparison. Transit managers will be able to monitor the system's on-time performance, and AVL will allow for enhanced fleet management and scheduling protocol.

Passenger Information Displays at the city's three transit centers will inform riders about the arrival times of their connecting buses. Additional kiosks with passenger information displays will be added later at bus stops.

Early implementation is scheduled for Fall 1996. City staff are expecting increased on-time performance for the transit system as a whole. Through integration of dispatching, maintenance and administrative departments, certain functions can be automated, realizing increased efficiency in every single Sun Tran department.

The city is investigating using the AVL system for giving buses preference at traffic signal and eventually linking the Sun Tran and Tucson Travel Vision databases.

2.2.4 The Living Laboratory

The City of Tucson is working closely with the University of Arizona's Systems and Industrial Engineering Department to test traffic-signal timing algorithms and video detection equipment. They are being tested at the UA's Living Lab, which comprises the intersection of Speedway Blvd. and Mountain Ave. and several other university-area intersections.

The Living Lab is a cooperative research project between the City of Tucson and the University of Arizona. It comprises several university-area intersections wired to collect traffic flow data. In addition to loop detectors embedded along Speedway Blvd., the lab has four Autoscope(R) cameras trained on the intersection of Speedway and Mountain. Researchers will apply the traffic data to algorithms they have spent years developing.

The algorithms were developed under the RHODES project. While the Living Lab will be operating on the Tucson arterial system, a variation called RHODES-ITMS, developed for diamond-shaped interchanges will be tested at freeway interchanges in Tempe, Arizona.

The Autoscope (R) Video Detection System is an example of the state-of-the-art in vehicle recognition technology. It can directly provide volume and vehicle-type information. The system, including the four cameras, was purchased by the City of Tucson. Soon, a fiber-optic link will transmit video and data directly to the researcher's desk. The next phase will be to build a link to the City of Tucson Traffic Management Center, so data and video will be available to city engineers.

The City of Tucson is among a long list of public and private partners involved in the research. The list includes Hughes Missile Systems Co., the Arizona Dept. of Transportation, Federal Highway Administration, and AT&T among others.

As the Living Lab expands to the north and south on Campbell Ave., more surveillance technology will be brought on-line.

2.2.5 Priority Emergency Vehicle Routing

All of Tucson's fire and paramedic vehicles are equipped with signal preemption devices to give them priority at traffic signals. As designated by the Chief of Police, selected law-enforcement vehicles are similarly equipped. Fire districts in adjacent jurisdictions are equipped with the same type of equipment for traffic-signal preemption. In addition, all emergency services operate under a single 911 emergency system dispatch center for coordination, computer-aided dispatch, emergency vehicle-location and mutual aid.

2.3 Statewide Scope

The Tucson metropolitan area received one of three early deployment grants awarded in Arizona. The Phoenix-area early deployment plan, administered by the Maricopa County Department of Transportation, was completed in October 1995. The entire Arizona Interstate Route 40 is also undergoing an ITS early deployment study. ITS strategic planning will help these regions determine their ITS priorities. Each project faced (or faces) the challenges of designing an integrated system that offers flexibility, interconnectivity, and interjurisdictional involvement. There needs to be a statewide context within which various ITS initiatives are not only compatible, but, more to the point, mutually reinforcing and building on each other to achieve greater effectiveness and efficiency of the system and its operation (responsiveness). These and other statewide ITS projects that have implications for the Tucson region are discussed below.

2.3.1 Phoenix ITS Strategic Deployment Plan

The TATTIP project manager participated in the Steering Committee for the Phoenix-area early deployment project. As the Phoenix project preceded the TATTIP, participating on that study's Steering Committee helped clarify tasks and anticipate problems.

It is important to sustain the spirit of cooperation that has characterized the association between PAG region with Maricopa County ITS proponents. The Phoenix metropolitan area will continue to provide a model for deployment of ITS in Arizona, particularly for freeways, and especially since the Phoenix metropolitan area is home to the ADOT regionwide freeway Traffic Operations Center. But more importantly, as a market develops for on-board navigation devices, it will be important that the ITS architecture that supports the delivery of real-time information be compatible between Arizona's largest metropolitan areas.

2.3.2 I-40 Corridor Early Deployment Plan

The entire Arizona Interstate Route 40 corridor was selected in summer 1995 by the FHWA as an ITS early deployment study corridor. This rural interstate corridor experiences large volumes of commercial vehicle traffic and seasonal tourist traffic, as well as sometimes severe winter weather.

Some ITS features are already in place. A monitoring system, called SCAN, warns ADOT personnel when hazardous weather conditions are likely to occur. SCAN has helped ADOT use their personnel, snow removal equipment and material more efficiently. "Smart" kiosks are also already deployed along the corridor.

The I-40 early deployment strategic plan will address additional ITS User Services needed on this corridor. As a component of the regionwide ITS system, the User Services deployed on the I-40 corridor should be compatible with other components. The statewide ADOT Traffic Operations Center will play a major role in disseminating throughout the state information about travel conditions on rural routes like I-40.

2.3.3 The ADOT Freeway Management System

ADOT has deployed a Freeway Management System (FMS) on Phoenix-area freeways. The FMS is an integrated system of CCTV, loop detectors, ramp meters, variable message signs, fiber-optic communications, interchange signals and drainage pump monitors. Operators at the Traffic Operations Center (TOC) have the capability of monitoring traffic conditions, identifying flow impediments, implementing appropriate management strategies, and providing critical information to travelers via signs and on-board devices, which are currently being tested.

First phase of deployment, covering 29 miles of freeway, is complete. The second phase is under construction. Upon completion of the third phase, scheduled to begin soon, the FMS will be deployed on a total of 60 freeway miles. The TOC is being considered as the information and management center for freeway segments in the Tucson region and along the I-40 corridor.

Software is being developed which will add traveler information services and enable local jurisdictions to connect via fiber-optic for surveillance and information sharing. In the meantime, a view from the FMS operations center can be accessed through the World Wide Web, and local TV stations are getting real-time video feed from closed-circuit TV cameras installed along the freeway.

As already mentioned, the ADOT Traffic Operations Center will serve as a clearinghouse for information about traffic and travel conditions for regions across the state of Arizona. Monitoring of a Tucson Freeway Management System could be augmented through the Phoenix operations center. Information about the Phoenix freeway system and conditions in between will be of interest to travelers in Tucson heading to Phoenix.

2.3.4 Expedited Crossing at International Borders (EPIC)

Expedited Crossing at International Borders (EPIC) is an operational test for facilitating international commercial vehicle operations at the Nogales, Arizona port of entry. It involves a computerized system that automatically identifies weight, driver, cargo, origin/destination and compliance information as the vehicle passes roadside scanners and weigh-in-motion scales. Nogales was chosen because it lies on a designated NAFTA corridor.

The project includes a database that will be shared among transportation, customs and law-enforcement agencies regulating U.S., Mexican and Canadian truck drivers. License Plate Recognition and electronic cargo seals are among the technologies being assessed.

During the 16 months of the operational test, approximately 500 international commercial vehicles will be outfitted with electronic transponders to automatically transmit credentials and other required documentation. Fifty to 100 of these vehicles will cross the border each day.

This is a public-private partnership lead by ADOT, consisting of Lockheed IMS, Hughes Aircraft, Farradyne Systems Inc., Western Highway Institute, JHK & Associates, and the University of Arizona.

As the major trade corridor passes through Tucson, this border-crossing project will have significant implications on ITS projects related to Commercial Vehicle Operations that may be developed in the PAG region.

Chapter 3. ORGANIZATION

3.1 Introduction

As previously mentioned, ITS deployment is based on identifying users, defining their needs and providing transportation services that address those expressed needs. This chapter begins with a brief discussion of who these "stakeholders" are. It is followed by a discussion of the organizational structure that framed the TATTIP for almost two years during which the study was carried out. Finally, Chapter 3 describes a generic process by which a typical ITS project will come to fruition.

3.2 Stakeholders

Because an Intelligent Transportation System and its components are geographically all-inclusive, cooperation among all levels of government is essential if successful deployment of ITS is to be achieved. The greater metropolitan Tucson area is fortunate to be characterized by enlightened government officials who have demonstrated their commitment to working together to achieve common goals. This attitude will serve well the implementation of ITS in Eastern Pima County. An excellent example is embodied in the existing intergovernmental agreements among the City of Tucson, Pima County and the Arizona Department of Transportation providing seamless operation of area traffic signals. Operation of the areawide Sun Tran bus system, as well as cooperative arrangements for air quality and ride-sharing initiatives provide additional illustrations.

Consistent with federal, state and local policies, the private sector plays an important role, one which is certain to increase, in existing and proposed ITS activities in the region. A highly visible and effective example is Skyview Traffic Watch, Inc., a for-profit service that regularly broadcasts real-time travel conditions on radio and television. Also, several firms are actively competing to provide high-quality fiber-optic communications links throughout the metropolitan area, thus making available a high-speed communications network.

Among the most important stakeholders are the traveling public, emergency service providers, and commercial vehicle operators, all of whom have a major stake in improvements to efficient, safe and convenient transportation brought about through the innovations of ITS.

3.3 The Study Organization

Overall administration of the early deployment Study was the responsibility of PAGTPD, the grant recipient. Responsibilities of PAGTPD included: overall project administration, assuring participation of other agency and individual stakeholders, financial and other record-keeping, publicity, formulation of advisory committees at various levels, and ongoing accountability to the Federal Highway Administration.

Study policy guidance was vested with the Study Advisory Committee (SAC) whose membership was comprised of a number of agency leaders. Technical advice with respect to Wide-Area-Network support for an ITS infrastructure was provided by various communications experts from both the public and private sectors. This advisory committee was designated TCOM 2000 Technical Advisory Committee (TAC) and was convened on an as-needed basis.

A User Services/Options Study Citizens Advisory Committee (CAC) was formed and served **as** an essential element of ongoing public involvement. The CAC contributed to the ranking of identified User Services, reviewed proposed performance criteria, and made recommendations concerning the geographic coverage of specific ITS projects under consideration for early implementation. Most importantly, the CAC represents an important segment of transportation users, who are now well-versed in ITS, and constitute a foundation upon which further public outreach can be based.

Finally, the University of Arizona Systems & Industrial Engineering Department, initially represented on the SAC, provided a high degree of expertise and support for the study. SIE researchers and the City of Tucson enjoy a mutually productive relationship in the application of new technologies to existing transportation facilities.

3.4 Introduction To The Project Implementation Flow Charts

The accompanying flow charts, Figs. 3.1 and 3.2, show the incremental processing of ITS projects from their conception, as part of the ITS Strategic Deployment Plan (SDP), through implementation and subsequent performance evaluation. They show a series of sequential, logical steps and illustrate input from appropriate advisory committees.

The charts are designed to facilitate a collective understanding among the stakeholders of how a project moves from concept toward implementation and what processes it is subjected to. They indicate that ITS projects are the result of the comprehensive and intensive planning process associated with the SDP. They help identify priorities, critical activities and funding decision points. They do not imply that stakeholders' understanding of a project develops incrementally; rather they are intended to show where stakeholder action is required.

Figure 3.1, Short-Term Project Implementation Process, illustrates the process by which projects identified in the Strategic Deployment Plan for short-term (O-5 years) implementation are progressed. These projects are described in the Strategic Deployment Plan in sufficient detail such that design may be undertaken without further project development

Figure 3.2, Long-Term Project Implementation Process, corresponds to projects identified in the Strategic Deployment Plan for longer term (5+ years) implementation. Because of uncertainties associated with the long-term planning horizon (in technology, existing infrastructure,

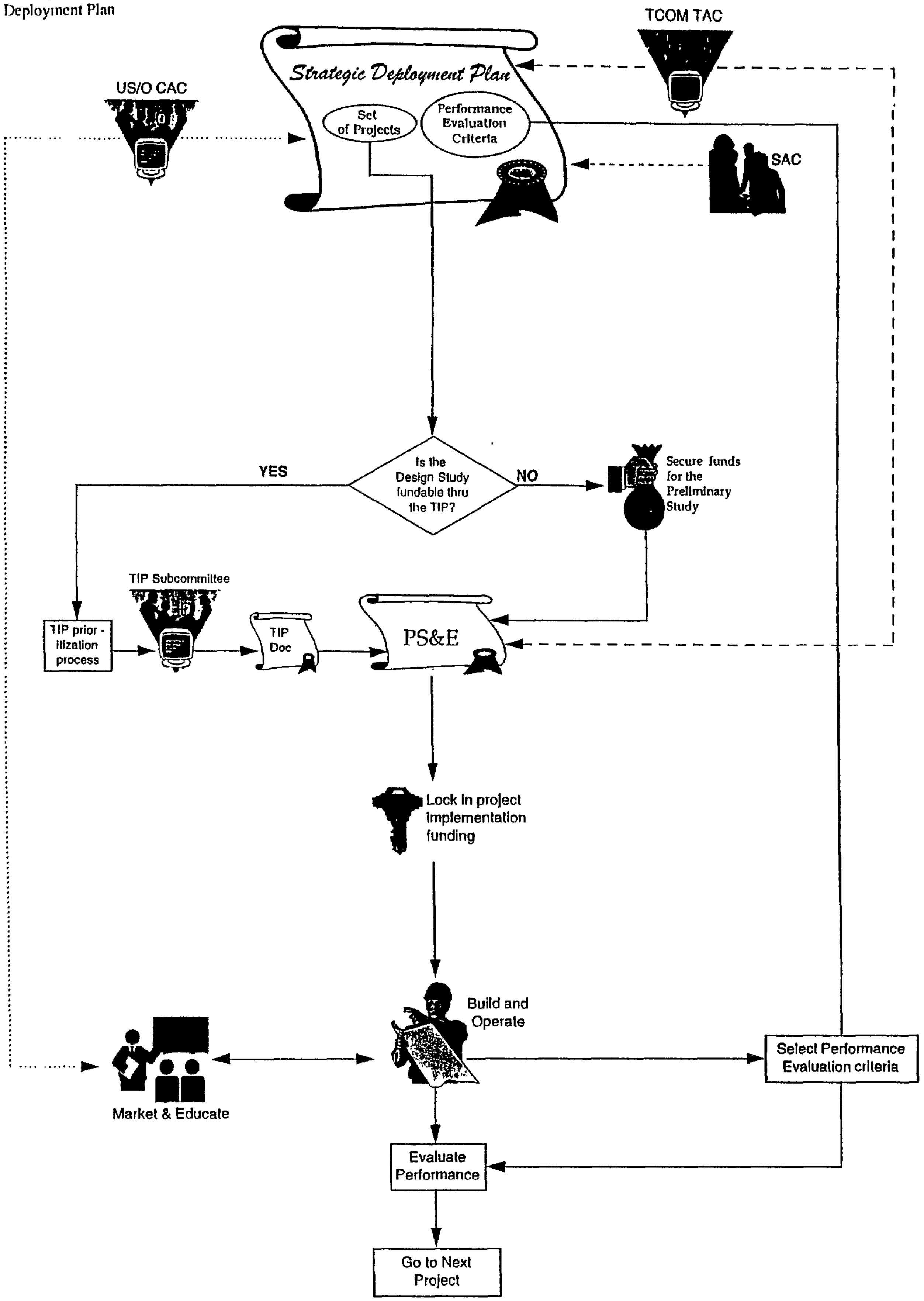


Fig. 3.1, Short Term Project Implementation Process

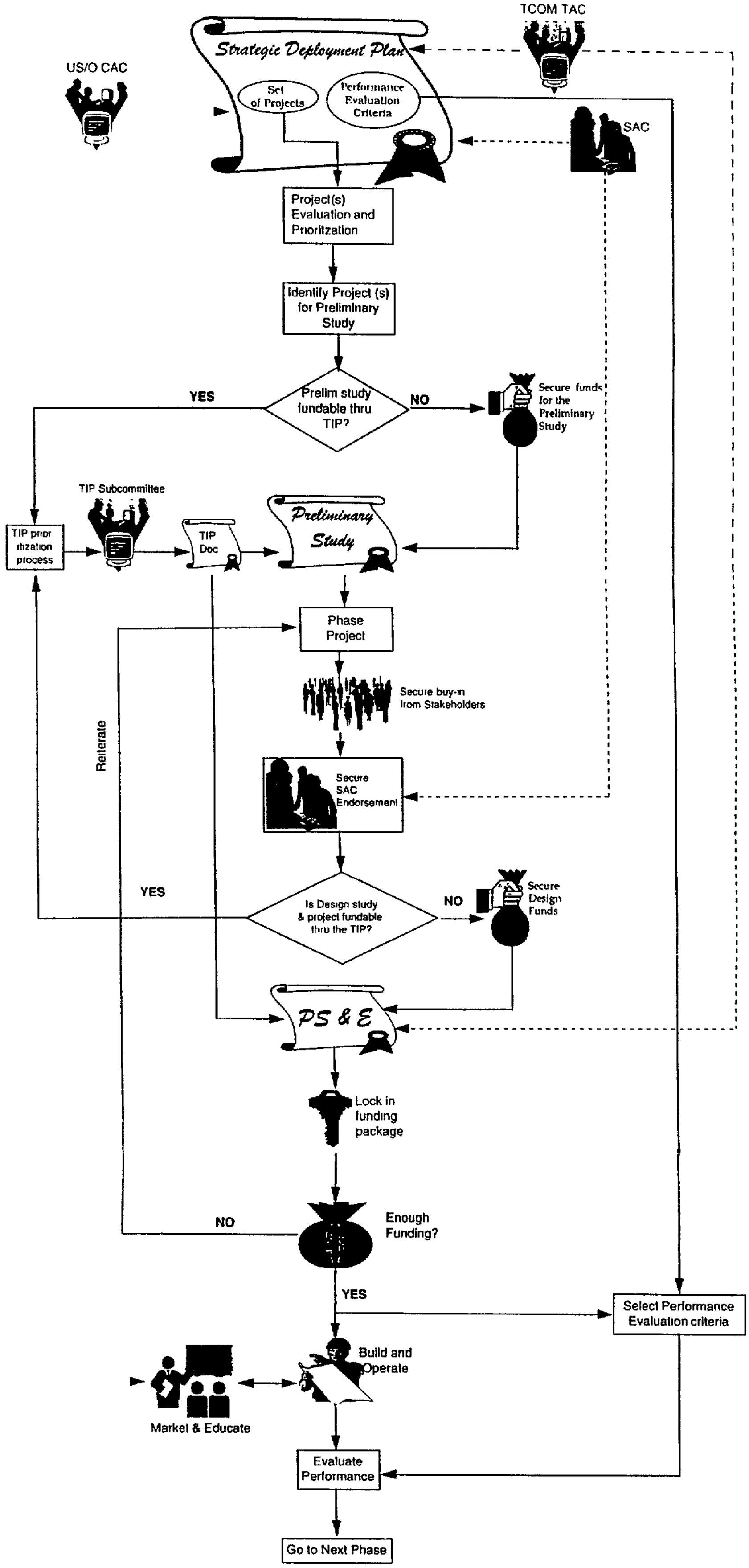


Fig. 3.2, Long-Term Project Implementation Process

etc.) a preliminary, or functional, study, is required. The additional steps shown in the chart extend the implementation process and length.

Wherever possible, a graphic image has been used to convey a process or a support group. The scroll-like image depicts a document. Rectangles and diamonds represent processes and decision points, respectively. Different line types are used to show connections among the various support groups.

3.5 What The Flow Charts Show

The following discussion explains the project implementation process, as illustrated in the accompanying flow charts. The discussion is broken down according to three critical documents that appear in the (long term) implementation process: the Strategic Deployment Plan; the Preliminary Study (long-term projects only), and; the Plans, Specifications and Estimates (PS&E).

3.5.1. The Strategic Deployment Plan

The process begins with the Strategic Deployment Plan, which is at the top of each flow chart.

Recommended within the Strategic Deployment Plan is a set of projects. Projects described in the Plan are identified for either short- or long-term implementation. Also contained in the SDP are performance evaluation criteria. As shown, these criteria come into play in the evaluation process following project implementation.

Candidate long-term projects will be prioritized according to criteria discussed in Chapter 4, Project Identification, and according to any additional criteria that may emerge.

Once a project is identified, a decision point is encountered: Should the preliminary study be funded through the TIP process? A “YES” response requires that the project enter the TIP prioritization process, be approved by the TIP subcommittee and be included in the TIP 5-year plan. “TIP”ically, projects are evaluated through this process for each new 5th year of the TIP.

Projects identified in the SDP for short-term implementation are, by definition, given high priority because of their importance in developing core ITS infrastructure. A more detailed discussion is in Chapter 4, Project Identification.

3.5.2 The Preliminary Study

This section refers only to projects identified in the Strategic Deployment Plan for long-term implementation.

Because ITS projects can be large in scope, it is reasonable to consider breaking down large projects for incremental implementation. That is why, as part of the preliminary study, the project should be evaluated for opportunities for “phasing,” or staged implementation.

The preliminary study is also the basis upon which "buy-in" is secured from stakeholders. The makeup of who the stakeholders are in any given situation depends on the project in question. Stakeholders may include any group that stands to benefit from an ITS project, e.g., ADOT, the City, the County, Federal Highway Administration, or community representatives. Stakeholder support is one basis upon which endorsement is sought from SAC (or ITS Oversight Committee).

Having garnered the necessary support, another decision point with regard to funding is encountered: Are the design study and project promising candidates for funding through the TIP? The "YES" branch feeds back into the TIP loop again. Once funding is secured, the project progresses to the design stage, the output of which is the Plans, Specifications and Estimates (PS&E) package used for solicitation of construction bids.

3.5.3 The PS&E

The PS&E is required before construction begins. Following the PS&E, the next step is to ensure that the funding package is "locked in." If this step determines that funding for long-term projects is insufficient, a loop is shown revisiting the phasing of the project.

Sufficient funding allows the project to move forward to implementation and operation. Performance evaluation criteria are selected from the SDP upon which to evaluate the project's performance.

Public awareness and understanding are critical to the usefulness of any ITS project. They occur simultaneously with the implementation and operation of the project. The Strategic Deployment Plan recognizes that ITS projects are atypical enough so as to require a well-thought-out public-education effort.

Being information based, ITS projects are ideally suited for the collection of data. Performance criteria established in the Strategic Deployment Plan are used to evaluate the project. Assuming successful performance, the next phase of implementation begins.

Chapter 4. IMPLEMENTATION PLAN

4.1 Introduction

In this chapter, specific steps for deploying ITS projects in the PAG Region are defined. An overall ITS concept is described, followed by description of a phased implementation approach. Deployment costs, including capital costs and operations and maintenance costs for each project and deployment phase are provided. Initial ITS deployment projects are defined in sufficient detail so that they can be carried forward directly into design and submitted for funding consideration. Finally, a general assessment of the expected benefits of deploying ITS in the PAG Region is provided.

4.1 .1 ITS User Services

The deployment of ITS is intended to provide regional benefits to travelers and transportation providers, both today and in the future. These benefits generally include:

- improved safety,
- increased efficiency of the transportation system,
- enhanced productivity for users of the system,
- enhanced mobility for area residents, and
- reduced energy and environmental impacts associated with transportation.

Users and providers of transportation in the PAG Region have identified ten (10) services which are felt will help to best achieve these benefits. These ITS User Services are listed below.

- Pre-Trip Traveler Information
- Traffic Control
- Incident Management
- En-Route Traveler Information
- Public Transportation Management
- Travel Demand Management and Operations
- Route Guidance
- Ride Matching and Reservation
- Personalized Public Transit
- Commercial Vehicle Electronic Clearance

4.1.2 System Requirements

In order to implement these User Services and achieve the desired benefits, the transportation system must be capable of performing certain functions. For the User Services listed above, these functions include:

- Monitoring of traffic conditions and fleet operating status.
- Data processing.
- Control of various elements of the transportation system.
- Interface with transportation providers and users.
- Navigational guidance
- Communication among field devices, control centers, and users.

Implementation of the required system functions will occur through expansion and upgrade of existing transportation infrastructure elements. The "core" system elements which support the necessary system functions are listed in Table 4.1. In metropolitan Pima County, many of these core ITS system elements either already exist to some degree, or are being planned for implementation.

Table 4.1
Status of ITS Core Element Deployment in the PAG Region

Core ITS Element	Deployment Status
Electronic Fare/Fee Payment System(s)	Smart Cards planned for transit.
Regional Multimodal Traveler Information Center	City of Tucson is implementing a traveler information center.
Traffic Signal Control System(s)	City of Tucson central signal system covers approximately 350 signals, including some ADOT and Pima County signals.
Freeway Management System	Concept design adopted by PAG regional council
Transit Management System	SunTran implementing GPS-based Transit Management System.
Incident Management Program	Individual agency programs in place.

4.2 ITS Concept

Deployment of ITS in the PAG Region is envisioned to result in establishment of each of the ITS core system elements to provide broad coverage of the metropolitan area, integration of each of these elements to allow for maximum effectiveness, flexibility and efficiency, and provision of those User Services which provide real and most significant benefits to transportation users and providers. A fully implemented system will establish:

- Real-time traffic monitoring on major routes to allow transportation agencies to detect and verify incidents. This monitoring capability will be accomplished by:
  - 0 vehicle detectors, either loop detectors or other non-intrusive detection technologies, at appropriate spacing,
  - 0 CCTV cameras to cover key route sections (i.e. major activity centers and high accident locations) and/or video based vehicle detection systems at major intersections,
  - 0 privatized MAYDAY services using digital cellular technology for accident reporting,
  - 0 hazard sensors to monitor roadway flooding and visibility.
  - 0 transit vehicles (express buses) equipped with AVL system acting as probes, and
  - 0 transit drivers reporting incidents using digital radio system.

- Enhanced traffic control on major routes to allow agencies to quickly respond to abnormal conditions and minimize impacts on travelers and the environment. This will include:
  - 0 bringing all signalized intersections into an existing or new system to allow for centralized monitoring and control,
  - 0 upgrade of intersection controllers to advanced capabilities as part of normal controller replacement programs,
  - 0 implementation of adaptive signal control algorithms
  - 0 installation of ramp metering on the I-10 and I-1 9 freeways,

- Modernized, interoperable traffic and transit management centers (TMCs) which, collectively, will provide system coverage 24-hours per day, 7-days a week.
  - 0 TMC architecture will be client/sewer based using PC workstations with graphical user interface.
  - 0 Video wall displays will be utilized.
  - 0 TMC interoperability and data/video sharing will be provided via a high bandwith wide area communications network (WAN). This WAN will be fiber optic based and will ultimately utilize SONET/ATM network management and transmission technology.

- Improved transit fleet management utilizing GPS with dead reckoning Automatic Vehicle Location(AVL) system (on-going). Transit management system will provide;
  - 0 transit vehicle performance monitoring,
  - 0 schedule adherence monitoring,
  - 0 real-time transit schedule information, and
  - 0 estimated arrival times at transit centers.

- Consolidation of all regional traffic, transit, rideshare, and road condition information into a central database for distribution to travelers, transportation agencies, fleet dispatch centers, emergency service dispatch, and private traveler information providers. To the extent possible, this function will be carried out as a public/private venture.

- Distribution of formatted traffic, transit, and road condition information to system users. Distribution will be performed by both public and private entities and will likely include the following methods;
  - 0 public and private kiosks,
  - 0 radio broadcast data service (RBDS) utilizing FM sideband frequency,
  - 0 cable-TV,
  - 0 broadcast radio,
  - 0 dial-up voice response system (i.e. Highway Advisory Telephone),
  - 0 Highway Advisory Radio (HAR),
  - 0 Changeable Message Signs (CMS), and
  - 0 Internet page.

- Electronic payment of transit fares utilizing “Smart Cards” or credit cards.
- Privatized route guidance service.
- Monitoring of commercial vehicle operations on l-10 and l-19 using standardized radio frequency (RF) tags.

4.3 ITS System Coverage

In order to assess alternative system architectures, develop a phased implementation approach, and identify probable program costs, it is necessary to define a system topology which can realistically be deployed within a reasonable time period. A system topology simply defines the area of coverage, both geographically and functionally. It answers the questions, where will the ITS system likely be deployed (i.e. on which roadways), and what level of ITS capability will be deployed on each roadway? This section describes the ITS system topology which is recommended for deployment in the PAG Region.

Geographic Coverage

The first step in defining the desired geographic coverage of ITS in the PAG Region was to identify candidate roadway segments on which deployment of the selected User Services would improve the efficiency and productivity of the transportation system. Based on input from the Community Advisory Committee, 21 routes in the metropolitan area were identified as candidates. These candidate routes are shown in Fig. 4.1. Essentially all of the major routes were considered for deployment of the selected User Services. However, a more realistic approach to ITS deployment in the PAG Region would include a more manageable number of routes.

In order to scale down the number of routes to be considered for ITS coverage, a generally qualitative assessment of each of the candidate routes was carried out. This assessment was primarily based on a review of the existing and future traffic and roadway characteristics on each route, keeping in mind the need to provide regional coverage and deploy ITS where it will likely provide the greatest benefit to the region. Utilizing data contained in the

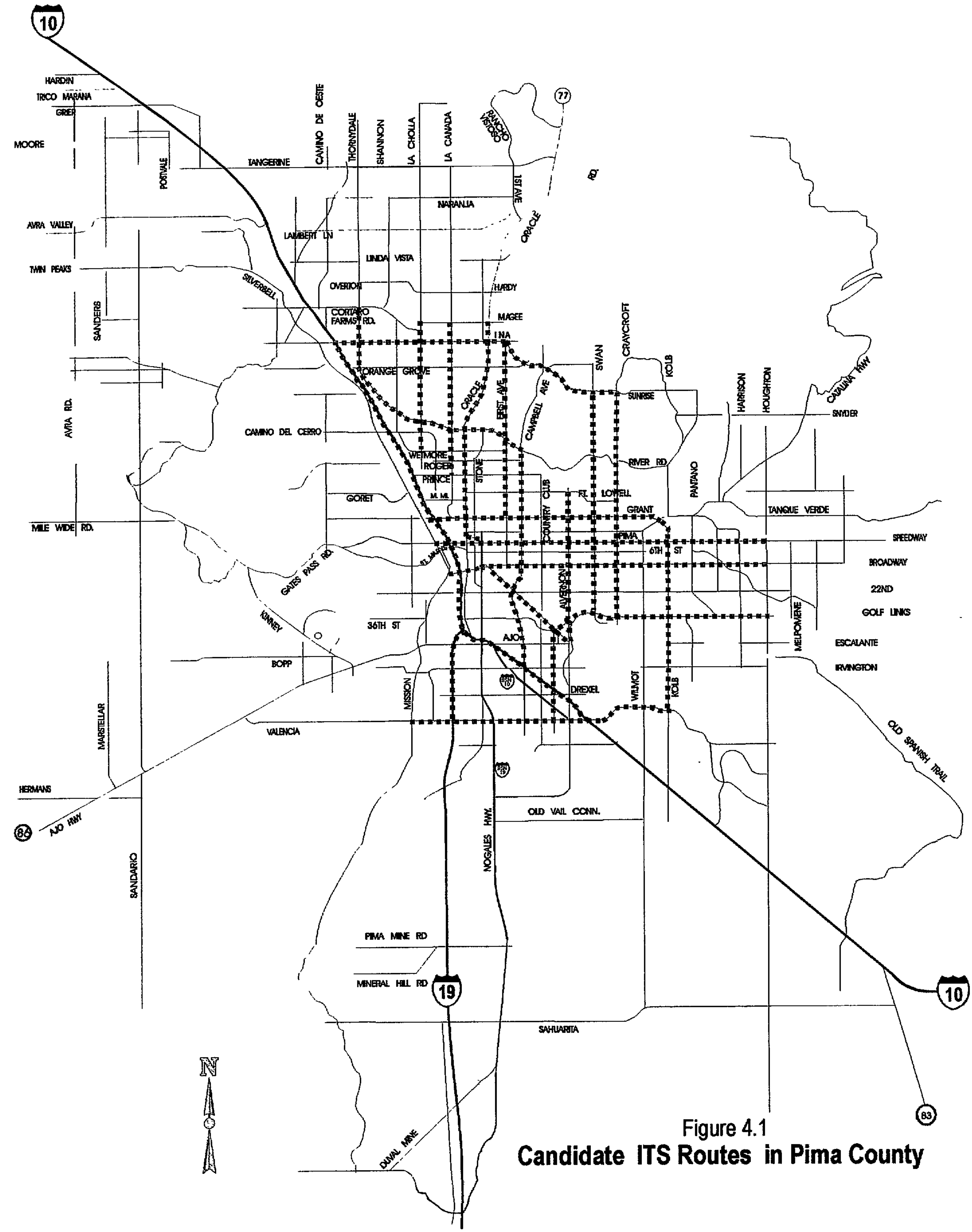


Figure 4.1
Candidate ITS Routes in Pima County

PAG Metropolitan Transportation Plan Update , dated Sept. 1994, the PAG Mobility Management Plan, and information provided by the City of Tucson, Pima County, Arizona Department of Transportation, and the Town of Marana, the characteristics of each candidate route were identified. These route characteristics are summarized in Table 4.2.

Route Evaluation Criteria

The following criteria were used to assess the candidate ITS routes.

- Traffic characteristics along the route, including existing traffic volumes and congestion levels, as well as projected demand in 2015. ITS is intended to serve the “users” of the transportation system in order to make it more efficient and productive. Thus, routes which currently, or are projected to carry the highest volumes of vehicular and passenger (i.e. transit) trips or exhibit the highest levels of congestion would likely benefit most from ITS deployment.

- Travel characteristics. The greatest benefits of ITS are expected to occur on routes which carry regional traffic (i.e. trips of greater than 5 miles) as opposed to routes which primarily serve local traffic needs. Therefore, routes which are characterized as commuter routes are most desirable.

- Transit routes. Incorporation of transit routes early on is important, particularly since Public Transportation Management is considered an important User Service in the region.

- National Route designation. Routes which are designated as part of the National Highway System as well as the region’s Congestion Management System will likely have greater opportunities for funding.

Table 4.2
Candidate ITS Route Characteristics

	Arterial	From:	To:	Total Miles	No. of Lanes (Miles)	Arterial Class	Volume: Existing[1] (1000's)	Volume: Forecast[2] (2015) (1000's)	Transit Route	Proposed National Highway System Link	MMP Roadway[3]	Miles of Congested Roadway (1995)[5]	# of Signalized Intersections	# of Signals on COT System	Planned Improvements: # of Lanes	Planned Improvements: Other
1	I-10	Ina Rd	I-19	12	4 (6) 6 (6)	Interstate	61 4 - 101	103 - 127	Yes	Yes	Yes	1 mile	11	7	8 Lanes	Freeway Upgrade
2	I-10	I-19	Valencia Rd.	7	6 (2) 4 (5)	Interstate	23 - 51	140 - 77	No	Yes	Yes	0 miles	9	2	6 lanes (3 miles) 4 lanes (5 miles)	Freeway Upgrade
3	I-19	I-10	Valencia Rd.	4.5	4 (4.5)	Interstate	36 - 45	104 - 81	No	Yes	Yes	0 miles	3	0	4 lanes	None
4	Aviation Parkway	Golf Links Rd.	Broadway Blvd.	4	4 (4)	Arterial Parkway	10.7	54 - 38	No	Yes	Yes	2 miles	4	0	4 lanes	Parkway Upgrade
5	Ina Road/Sunrise Drive	I-10	Craycroft	12	4 (11) 2(1)	Principal Arterial	25.7 - 36.9	168 - 83	Partially	No	Yes	4 miles	20	1	4 lanes	Arterial Upgrade
6	Orange Grove Road	I-10	Skyline	7	6 (2) 2 (3) 4 (1) 2 (1)	Principal Arterial	12.3 - 17.5	105 - 99	No	Yes	Yes	6 miles	9	1	6 lanes (5 miles) 4 lanes (1 mile)	Arterial Upgrade
7	River Road	La Cholla Blvd.	Campbell Ave.	4.5	2 (3) 4 (.75) 2 (.75)	Principal Arterial	13.9 - 21.4	22 - 53	Partially	Yes	Yes	3.5 miles	2	3	4 lanes	Arterial Upgrade
8	River Road	Campbell Ave.	Swan Rd.	3.6	2 (3.6)	Minor Arterial	27.4 - 22.3	58 - 52	No	No	Yes	3 miles	3	4	4 lanes	Arterial Upgrade
9	Grant Road	Silverbell Rd.	Kolb Rd	10	4 (6) 6 (4)	Minor Arterial, Principal Arterial	29.1 - 49.2	19 - 53	No	No	Yes	10 miles	15	15	4 lanes (0.5 miles) 6 lanes (9.5 miles)	Arterial Upgrade GSI[4] (1)
10	Speedway Blvd.	Silverbell Rd	Houghton Rd.	14	6 (14)	Minor Arterial, Principal Arterial	14.3 - 53.1	7.4 - 103	Yes	Yes	Yes	5 miles	27	27	4 lanes (0.5 miles) 6 lanes (9.5 miles)	Arterial Upgrade GSI[4] (1)
11	Broadway Blvd.	Silverbell Rd.	Houghton Rd.	13.5	4 (3.5) 6 (8) 2 (2)	Minor Arterial, Principal Arterial, Minor Arterial	12.0 - 54.7	7.4 - 68	Yes	Yes	Yes	10 miles	34	34	4 lanes (0.5 miles) 6 lanes (9.5 miles)	Arterial Upgrade GSI[4] (7)
12	22[nd] Street	I-10	Houghton Rd	12.5	4 (5) 6 (6.5) 4 (1)	Minor Arterial, Principal Arterial, Minor Arterial	31 4 - 45 4	61 - 41.7	Partially	Partially	Yes	10 miles	24	24	3 lanes (0.3 miles) 4 lanes (2 miles) 6 lanes (8 miles)	Arterial Upgrade GSI[4] (3)
13	Golf Links Road	Aviation Pkwy.	Houghton Rd.	8	6 (6.8) 4 (1.2)	Arterial Parkway, Principal Arterial	38.7 - 20.7	102 - 106	Yes	Yes	Yes	2 mile	8	8	4 lanes (2 miles)	Parkway, GSI[4] (1), Arterial Upgrade (1 mile)
14	Ajo Way	Silverbell Rd	Palo Verde Ave.	2.2	4 (2.2)	Principal Arterial	26.9	31 - 28	Yes	Yes	Yes	1 mile	9	9	4 lanes (2 miles)	Arterial Upgrade GSI[4] (1)
15	Irvington Road	I-19	I-10	4	4 (4)	Minor Arterial	23.2 - 16	22 - 17	Yes	Yes (partially)	Yes	2 miles	8	8	4 lanes (2 miles)	Arterial Upgrade
16	Valencia Road	Silverbell Rd.	Kolb Rd	11	6 (8) 4 (3)	Principal Arterial	13.2 - 1.6	36 - 21	Yes (partially)	Yes	Yes	1 mile	13	13	4 lanes (1 miles)	Arterial Upgrade
17	Oracle Road	Tangerine Rd.	Magee Rd.	6	6 (3.5) 4 (2.5)	Major Arterial	24 1 - 30.8	76	No	No	Yes	5 miles	4	4	6 lanes (5 miles)	GSI[4] (4)
18	Oracle Road	Magee Rd	Speedway Blvd.	8	6 (8)	Principal Arterisl	41.2 - 33.2	93 - 87	Yes	Yes (partially)	Yes	7 miles	12	12	6 lanes (7 miles)	None
19	Thornydale Road	Tangerine Rd.	Orange Grove R	7	2 (7)	Collector, Minor Arterial, Principal Arterial	18 3 - 1 7	55 - 54	No	No	Yes	2 miles	7	5	4 lanes (1 mile) 6 lanes (2 miles)	Arterial Upgrade
20	La Cholla Blvd	Magee Rd.	River Rd.	3	2 (0.5) 4 (2) 2 (0.5)	Principal Arterial	15.2 - 18.8	30 - 54	No	Yes	Yes	1.5 miles	5	3	6 lanes (5 miles)	Parkway Arterial Upgrade
21	La Canada Drive	Hardy Rd.	Prince Rd	6	2 (.6) 4 (1.4)	Minor Arterial	14 1 - 27.2	50 - 28	No	No	Yes	2 miles	0	0	6 lanes (8 miles)	Arterial Upgrade
22	1[st] Ave	Ina Rd	Broadway Blvd.	7	2 (3) 4 (4)	Minor Arterial	9 3 - 21 3	27 - 28	Yes (partially)	No	Yes	7 miles	9	9	2 lanes (0 5 miles) 4 lanes (7.5 miles)	Arterial Upgrade Freeway Upgrade

1 1993 traffic volumes - PAG
2 2015 traffic forcasts - PAG
3 Mobility Management Plan - PAG (1994)
4 GSI - Grade Separated Intersection
5 PAG Metropolitan Transportation Plan (1994)

Table 4.2 (cont.)
Candidate ITS Route Characteristics

	Arterial	From:	To:	Total Miles	No. of Lanes (Miles)	Arterial Class	Volume: Existing[1] (1000's)	Volume: Forecast[2] (2015) (1000's)	Transit Route	Proposed National Highway System Link	MMP Roadway[3]	Miles of Congested Roadway (1995)[5]	# of Signalized Intersections	# of Signals on COT System	Planned Improvements: # of Lanes	Planned Improvements: Other
23	Campbell Ave.	River Rd.	Broadway Blvd.	4.4	4 (2.2) 6 (2.2)	Minor Arterial, Principal Arterial	28.3 - 39.8	44 - 52	Yes	Yes	Yes	2 miles	11	11	4 lanes (1 mile) 6 lanes (1 mile)	GSI[4] (3)
24	Kino Blvd.	Broadway Blvd.	I-10	2.25	6 (2.25)	Arterial Parkway, Principal Arterial	30.9 - 26.2	70 - 37	Yes	Yes	Yes	4 miles	4	4	4 lanes (2 miles)	GSI[4] (1)
25	Alvernon Way	River Rd.	Valencia Rd.	10.2	6 (10.2)	Minor Arterial, Principal Arterial, Minor Arterial	16.8 - 35.9	52 - 27	Yes (partially)	Yes (partially)	Yes	1 mile	12	12	4 lanes (2 miles) 6 lanes (4 miles)	Arterial Upgrade
26	Swan Road	Sunrise Rd.	Golf Links Rd.	8.5	4 (8.5)	Principal Arterial, Minor Arterial	26.6 - 21.6	12 – 21	Yes (partially)	No	Yes	1.5 miles	7	7	4 lanes (5 miles)	GSI[4] (2)
27	Kolb Road	Grant Rd	Valencia Ave.	8	6 (5.5) 4 (2.5)	Principal Arterial	36.3 - 46.5	33 - 25	Yes (partially)	Yes	Yes	5 miles	10	10	6 lanes (4 miles) 4 lanes (1 mile)	GSI[4] (3)
28	Craycroft Road	River Rd.	22nd Blvd.	4.75	4 (3.5) 6 (1.25)	Minor Arterial	26.6 - 26.4	31 - 22	Yes	No	Yes	4 miles	6	6	4 lanes (3 miles) 6 lanes (1 mile)	GSI[4] (2)
29	River Road	La Cholla Blvd.	Thornydale Ave.	2	4 (2)	Principal Arterial	None	22	No	No	Yes	0 miles	1	1	2 lanes (2 miles)	Arterial Upgrade

1. 1993 traffic volumes - PAG.
2. 2015 traffic forcasts - PAG
3. Mobility Management Plan - PAG (1994)
4 GSI - Grade Separated Intersection
5. PAG Metropolitan Transportation Plan (1994)

- Existing and committed levels of ITS infrastructure. Routes on which necessary core elements of ITS exist or are planned, (including interconnected or centrally monitored traffic signals, vehicle detection, and communications) pose opportunities for implementing ITS at a lower cost.

- Jurisdictional coverage. Successful deployment and funding of ITS in the PAG region will require that all jurisdictions share in the system functions and benefits which will be possible through ITS.

In addition to these criteria, ITS routes which would complement each other by providing accessible alternatives to the traveler are desirable. Therefore, knowledge of existing travel patterns needed to be considered. Identification of the most desirable alternate route should a major regional route experience a high level of congestion, was necessary.

Recommended ITS Routes

Based on the qualitative assessment, 12 routes were selected for ultimate ITS coverage. They are shown in Fig. 4.2 and listed in Table 4.3 on page 47.

The recommended ITS routes provide broad regional coverage of the metropolitan area and focus deployment of advanced detection, monitoring, and communications on major carriers of regional traffic. It is important to note that this recommended coverage is considered to define a realistic target for deployment of ITS in the region, and for the purposes of this project, provides a basis for estimating probable deployment costs. As the regional transportation planning process continues and transportation priorities change, specific opportunities for ITS deployment will grow and wane. Thus, it is probable that ITS coverage in the region ultimately will have a somewhat different topology than that which is currently recommended.

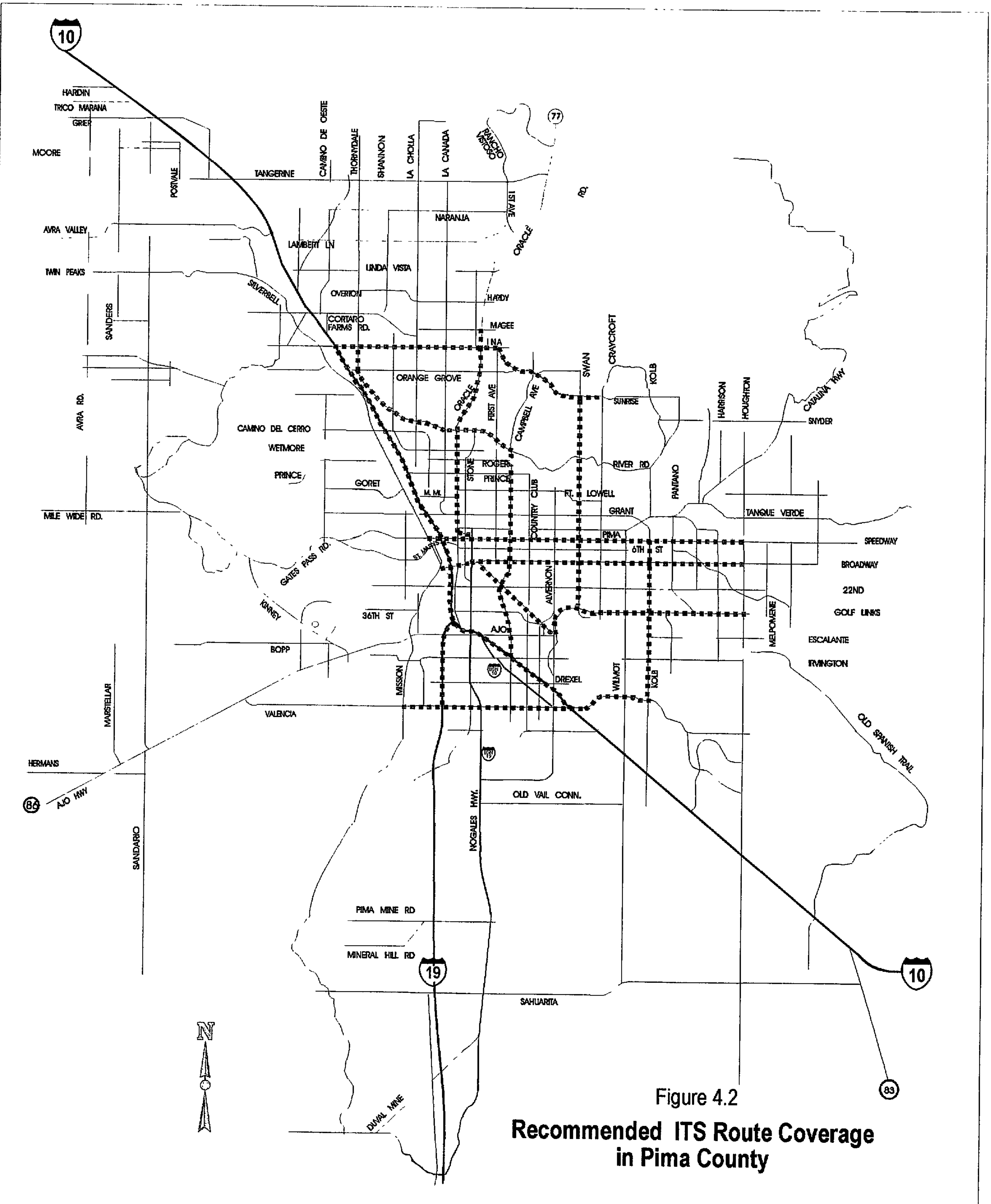


Figure 4.2

Recommended ITS Route Coverage in Pima County

Table 4.3

Recommended ITS Routes in Pima County

Roadway	From	To
I-10	Ina Road	Valencia Road
I-19	I-10	Valencia Road
Oracle Road/Stone Ave	Magee Road	Speedway Boulevard
Campbell Avenue/Kino Parkway	River Road	I-10
Swan Road	Sunrise Drive	Golf Links
Kolb Road	Speedway Boulevard	Valencia Road
Ina Road/Skyline Drive/Sunrise Drive	Craycrofl Road	I-10
River Road/Thorneydale Avenue	Campbell Avenue	Ina Road
Speedway Boulevard	Houghton Road	Silverbell Road
Broadway Boulevard	Houghton Road	Silverbell Road
Golf Links/Aviation Parkway	Houghton Road	Broadway Boulevard
Valencia Road	Kolb Road	Mission Road

4.4 Deployment Strategy

Implementation of the core ITS infrastructure elements is intended to establish the basis for near term system deployment and create opportunities for future widespread deployment of advanced ITS user services. However, considering available transportation funding levels, difficulties inherent in large scale systems integration, and the need to establish a firm understanding of the impacts, both benefits and costs, of ITS, deployment of ITS in Pima County should be modular and as needs develop. Initial, Phase 1, deployment should focus on establishing a complete system (i.e. implementation of each of the core infrastructure elements), although on a manageable and fiscally realistic scale.

Initial deployment of a smaller scale, yet complete system of useful, usable components will provide a testbed from which life-cycle costs, including operations and maintenance costs, as well as benefits to both transportation users and providers can be identified and assessed. This approach will also allow transportation providers to focus on achieving a high level of systems integration and developing appropriate operational procedures and policies, thereby resulting in smoother overall operation. Finally, and perhaps of greatest importance, a complete, yet small scale initial ITS deployment will provide transportation users the opportunity to experience the benefits of ITS and buy into the system as a necessary and appropriate component of the overall transportation in the PAG Region.

Therefore, initial ITS deployment in the PAG Region will be at a manageable scale. As such, it is recommended that the early deployment projects should include I-10, Oracle Road, Speedway Boulevard, Broadway Boulevard, and Ina Road/Skyline Drive/Sunrise Drive. Initial coverage is shown on Figure 4.3. These routes are considered to offer the best opportunity for initial ITS deployment and provide good regional coverage, thereby affording a larger proportion of the population to experience the benefits of ITS.

As needs arise and additional funding becomes available, the initial system will be expanded, both geographically and functionally (i.e. additional user services), in a modular fashion since the necessary core ITS infrastructure elements will already be in place and operational.

Finally, it cannot be more strongly emphasized that the deployment of ITS must build upon the existing systems infrastructure which is already, or soon to be, in place. This infrastructure includes:

- City of Tucson's central signal system, traffic management center, and traveler information system,
- Sun Tran's AVL transit Management System,
- I-1 0 FMS communications conduit, and
- agency-owned fiber optic communications facilities.

<u>Communications</u>

The TCOM 2000 study defined a wide-area network (WAN) communications architecture to support the deployment of ITS in the PAG Region. The architecture is comprised of the following subnetworks.

- Backbone Subnetwork
- Transit Subnetwork
- Traveler Information Subnetwork
- Roadside Subnetwork

Each subnetwork has been defined in order to support the communications requirements of near-term ITS deployment at reasonable cost, yet allow for expansion and upgrade as needs arise. The characteristics of each of the recommended subnetworks are summarized below.

Backbone Subnetwork

The initial communications backbone will provide interconnection between TMC's and other agencies. Redundant links will be created between the City of Tucson TMC, the SunTran/VanTran TMC, and the ADOT Tucson District Headquarters (FMS TMC) utilizing a combination of fiber for the primary link, and microwave or leased TI for the redundant link. Linkages to other transportation and emergency service agencies will be made utilizing leased

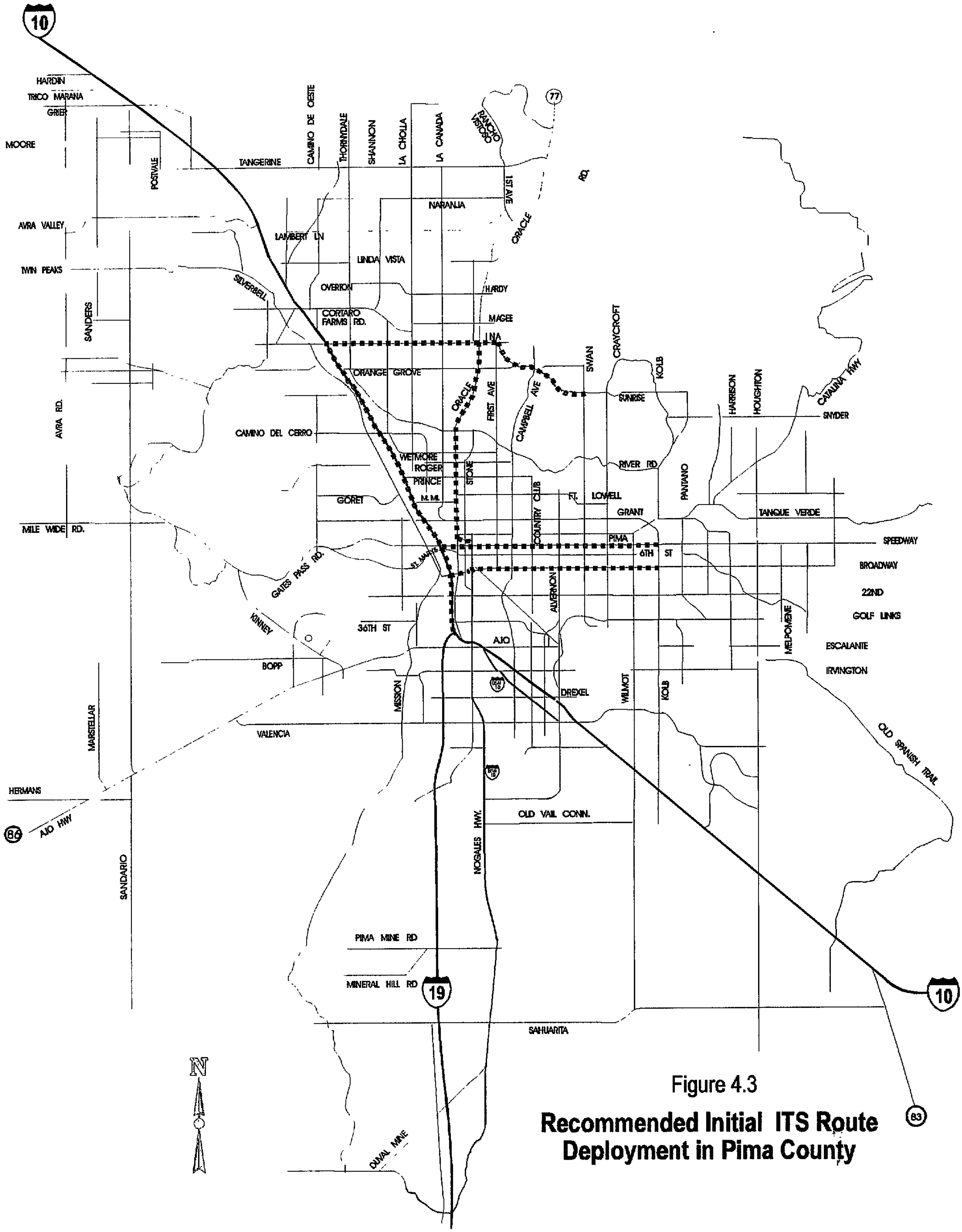


Figure 4.3

Recommended Initial ITS Route Deployment in Pima County

data services, and microwave. As communications needs expand, additional fiber optic links will be established and advanced transmission technologies and protocols implemented. The WAN will likely evolve into an ATM/SONET based network.

Transit Subnetwork

The recommended transit subnetwork will utilize wireless communications technologies to provide communications with transit vehicles and transit centers. Communications between the SunTran/VanTran TMC and the transit fleet will be made using digital radio. A digital radio communications network is currently being implemented on the transit fleet. Links between the TMC and transit centers will be made using microwave radio. As the backbone subnetwork expands and evolves to include more fiber optic cable, opportunities to link various transit centers to the fiber backbone may arise.

Traveler lnforma tion Subnetwork

Access to traveler information services provided by the Regional Traveler Information Center will be provided by public carrier. Links between public kiosks will be made using leased service or available copper wire, fiber optic cable, or microwave facilities.

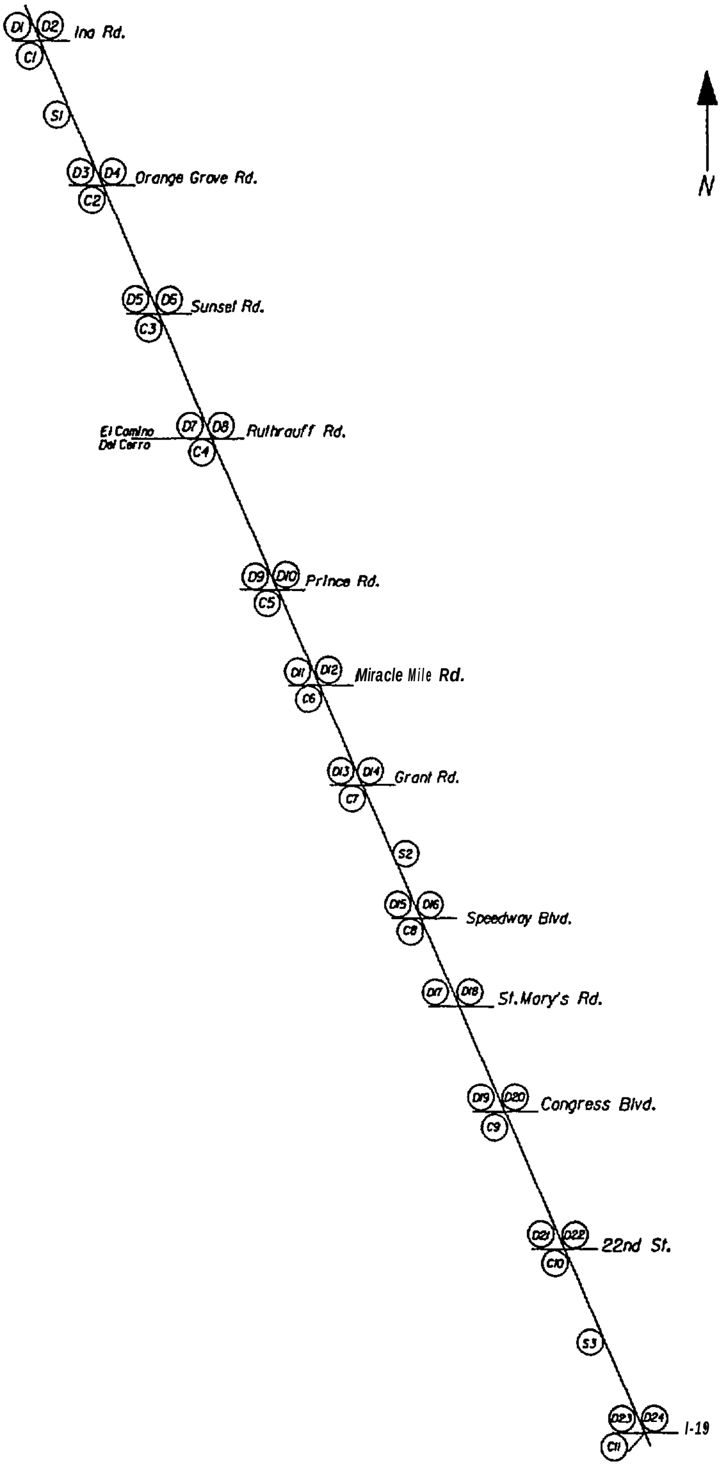
Roadside Subnetwork

The architecture for providing communications between TMCs and roadside devices allows for the use of fiber optic, microwave, and leased telephone service to create the desired linkage either directly with the TMC or with another hub/node on the backbone subnetwork. Links requiring high bandwidth to support video can be established using dedicated fiber optic or microwave, or leased services such as ISDN or T1. Low speed data links can be established using dedicated fiber optic or microwave, or leased services such as ISDN or ADN. The selected communications linkage will depend upon such factors as desired quality of video, location of devices relative to backbone hubs, and whether full time or part time communications is needed.

Phase 1 Deplovment

Initial, Phase 1, system deployment will focus on implementation or enhancement of existing field infrastructure needed to provide traffic monitoring and control capabilities to support a regional traveler information system (both pre-trip and en-route). Specific Phase 1 elements will include:

- Implement elements of the planned Freeway Management System (FMS)
  - 0 on I-10, as shown in Fig. 4.4, Phase 1 FMS will include: system detection stations utilizing loop detectors at l-mile spacing,
  - 0 CCTV cameras at l-mile spacing to provide video surveillance for incident and construction management purposes.
  - 0 full matrix changeable message signs (CMS) which can be relocated along the I-10 corridor as needed for construction management,
  - 0 highway advisory radio (HAR) to provide updates of on-going and planned corridor construction activities on the I-10 corridor and real-time information to freeway travelers of incidents on I-1 0, and on I-1 9.
  - 0 completion of the on-going ADOT/City program to upgrade freeway interchange controllers along I-10, tying them into the City's traffic signal system,
  - 0 deployment of video-based vehicle detection systems (i.e Autoscope, Trafficam, etc) at interchange signals as is currently planned for the I-l 0 frontage road reconstruction projects,
  - 0 continued implementation of conduit along I-10 as part of the frontage road reconstruction for use by the FMS to provide communications and power distribution,
  - 0 implementation of a fiber optic communications backbone, including communications hubs, along I-10 as part of the FMS. Deployment of fiber, utilizing existing and planned conduit, will occur as conduit and funding becomes available,
  - 0 development of an ADOT Tucson District TMC capable of operating the FMS to the level to which it is deployed. Monitoring of the FMS during off-hours and on weekends may be performed by the ADOT Statewide Operations Center located in Maricopa County. Leased communications will provide the necessary interconnectivity.
- use of leased communications to interconnect the FMS field elements (CCTV, CMS,



Legend

C = Video Camera

D = Detector Station

S = Changeable Message Sign

Catalina Engineering, Inc.

FIGURE 4.4
PAG ITS Strategic Deployment Plan
Freeway Management System - Initial Project

and HAR) to the ADOT District TMC, and

- Install an advanced traffic management system (ATMS) on the initial arterial routes as shown in Fig. 4.5 and as previously defined (see Fig. 4.3). Deployment on these routes will include:
  - 0 arterial system detector stations utilizing loop detectors, interconnected to signalized intersections which are tied into the City of Tucson's central signal control system. These stations, of which some are already in place, will typically be at 1 mile spacing.
  - 0 deployment of video-based vehicle detection systems at major intersections (typically l-mile spacing) for dual purpose of vehicle detection and incident management,
  - 0 continuation of the program to bring Pima County, South Tucson, Marana, Oro Valley, and ADOT signals into the City of Tucson central signal control system. This will require controller, detection, and communications upgrades,
  - 0 deployment of a CCTV camera covering an arterial segment adjacent to a key traffic activity center (i.e. Tucson Mall, Park Mall, University of Arizona, etc.) or on a high accident arterial segment to test benefits towards arterial incident management and public acceptance,
  - 0 use of leased communications to bring video images from video-based detection systems and CCTV back to the City of Tucson TMC,
  - 0 upgrade of the Tucson TMC to provide the capability for operating the arterial traffic management elements, and
  - 0 field testing of a transit vehicle pre-emption system.
- Complete AVL system implementation on the SunTranNanTran transit fleet. Utilize the transit fleet to report incidents back to the City of Tucson TMC.
- Link TMCs (Tucson, ADOT, SunTranNanTran) with fiber based wide area network (WAN). Utilize existing/committed agency communications infrastructure including FMS conduit, and City of Tucson fiber, conduit, and CAP dark fibers. Install communications hubs at each TMC.
- Develop a Regional Traveler Information Center (RTIC) which will serve as a clearinghouse for dissemination of information to the public and commercial interests. Opportunities for participation from private sector traffic information providers (i.e. traffic reporters, radio stations, TV stations) will be strongly encouraged for this purpose. Pre-trip traveler information will be disseminated via cable TV, electronic bulletin board or Internet page, traveler advisory telephone, and public and private kiosks.

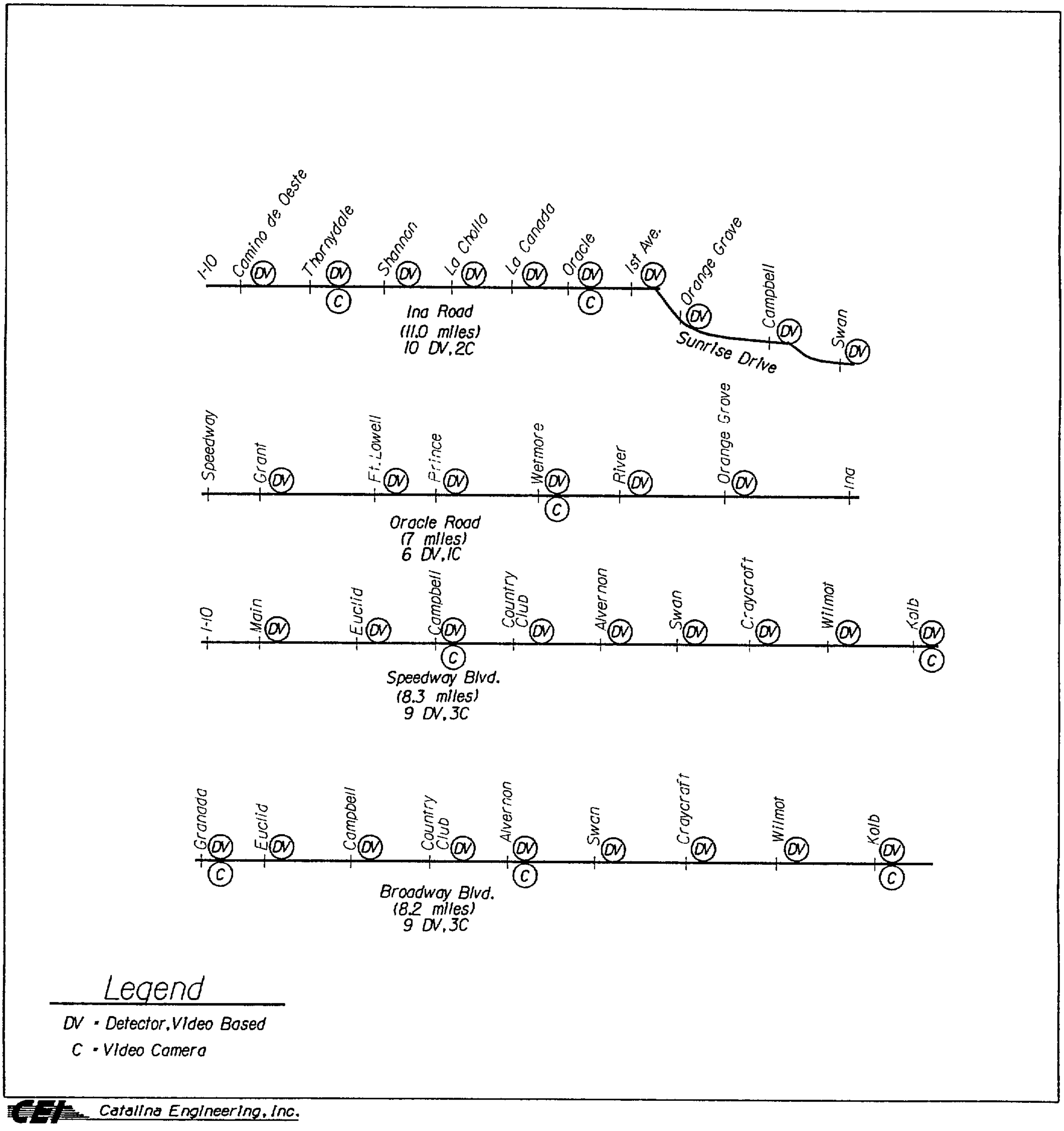


FIGURE 4.5
PAG ITS Strategic Deployment Plan
Arterial Management System - Initial Project

- Use leased communications to link other entities (i.e. other local agencies, emergency services, private traffic information providers) to TMC's and a regional traveler information center.

Deployment Schedule

Phase 1 deployment is expected to occur over a five year period beginning in 1996 with the initial 1-2 years spent on system design. Priority will be given to developing the FMS, ATMS, and Regional Traveler Information Center. Deployment of FMS elements will be to a level determined to be consistent with fiscal resources available to install, operate, and maintain the system. Use of leased communications for the initial FMS deployment and for establishing TMC links is a viable option which will be considered during system design.

This Strategic Deployment Plan serves as a starting point from which full deployment of ITS core infrastructure will occur. In order to initiate this program, three projects have been defined in detail in order to begin the approval and funding process. These projects, for which detailed descriptions are provided in Appendix C, focus on the priority previously mentioned.

Phase 2 Deployment

Phase 2 deployment will include expansion of coverage of the arterial and freeway traffic management systems on the recommended ITS routes, upgrade of existing TMCs, expansion of the Regional Traveler Information Center, continued privatization of ATIS elements, expansion and upgrade of the transit management system, as well as expansion and upgrade of the WAN. Specific projects which are included in Phase 2 are defined in the following sections.

FMS Expansion

Deployment of traffic monitoring (vehicle detection, CCTV), and en-route traveler information (CMS) will be expanded to include the following freeway sections:

- I-l 0; I-1 9 to Valencia Road (4 miles)
- I-19; I-10 to Valencia Road (7 miles)

In addition to the Phase 1 capabilities, traffic monitoring and control capabilities of the FMS will be expanded to include the following.

- Ramp metering will be installed at all on-ramps along the I-1 0 and I-1 9 freeways.
- Commercial vehicle monitoring will be enhanced by installation of weigh-in motion stations equipped with RF beacons.
- The FMS fiber backbone will be expanded.

- The ADOT Tucson District TMC will be upgraded to expand its monitoring and control capabilities, and will include additional video display equipment, an additional workstation, ramp metering control software, and communications equipment. Consolidation of the FMS and ATMS TMC functions may be possible and will be considered. If desired by ADOT and the local transportation agencies, intelligent gateways will be installed at both TMCs to allow for permissive control capability.

Arterial ATMS Expansion

Deployment of advanced traffic monitoring (vehicle detection and CCTV) will be expanded to include the following route sections:

- Swan Road; Sunrise Drive to Golf Links Road (8.5 miles)
- Golf Links Road/ Aviation Parkway; Kolb Road to Broadway Boulevard (8 miles)
- Kolb Road; Speedway Boulevard to Golf Links Road (7 miles)
- Valencia Road; I-19 to I-10 (6 miles)
- Campbell Avenue/Kino Parkway; River Road to I-10 (8 miles)
- River Road; Campbell Avenue to La Cholla Boulevard (4 miles)

Phase 2 deployment also will include the following elements.

- All traffic signal controllers will be brought into the City of Tucson's centralized system.
- System detection utilizing loop detectors and video-based detectors will be installed at approximately l-mile intervals to cover major arterial intersections. Video-based detection systems are planned, however, based on the resulting operational/maintenance impacts learned from deployment of this technology in Phase 1, alternate detection technologies, including loop detectors and other devices may be selected.
- CMS will be installed at locations approaching the I-10 or I-19 freeways to provide motorists information on freeway corridor conditions.
- CCTV cameras will be installed at selected high accident locations and activity centers.
- The City of Tucson TMC will be expanded to include an additional work station, video display/control equipment, and an intelligent gateway which allows for permissive control if desired.

- Communications to field elements by leased service is planned, however, fiber optic and microwave may also be utilized depending upon opportunity and cost.

Transit Management System Expansion.

The SunTran/VanTran TMC will be upgraded, as needed, to include additional video display capabilities, an operator workstation, and system capabilities, including real-time transit schedules, and automated transit arrival time estimates. Digital radio and AVL equipment will be installed on additional transit vehicles in the fleet. CCTV will be installed at transit centers to provide surveillance capabilities.

Regional Traveler Information Center Expansion

The Traveler Information Center will be expanded to provide improved utility and information accessibility. Deployment of privately funded information kiosks and radio broadcast data systems (RBDS) will be encouraged. Opportunities for continued privatization of traveler information systems will be sought. An interactive rideshare system will be implemented to enhance the existing program currently run by the Pima Association of Governments.

WAN Expansion

Additional fiber links will be added to the WAN communications backbone. Implementation of fiber will depend upon communications needs, with a strong emphasis on the need to receive video. Likely candidates for fiber linkage include Pima County Sheriff Department Headquarters, and Department of Public Safety District Headquarters. Deployment of a fiber optic backbone along ITS routes will depend upon need and opportunities for implementation as part of infrastructure improvement projects. TMC and FMS field communications hubs will be upgraded to a SONET network.

Deployment Schedule

Phase 2 deployment will likely occur in years 5-10.

<u>Phase 3 Deployment</u>

In Phase 3, deployment of Advanced Traffic Management Systems on the recommended ITS routes will be completed, the WAN fiber backbone will continue to be expanded, and additional, privatized traveler information services will be provided. Specific elements which are included in Phase 3 include:

- Deployment of advanced traffic monitoring (vehicle detection, CCTV) and en-route driver information (CMS) on 24 miles of recommended arterial ITS routes.
- Additional detector stations will be installed on I-10 and I-19 (l/2-mile spacing) to provide the FMS with enhanced incident detection capabilities.
- Additional, privatized traveler information systems, including in-vehicle navigation will be added.
- The recommended SONET based WAN fiber optic backbone will be completed. Additional inter-agency linkages, including Pima County Operations, South Tucson, Marana, and Oro Valley will be implemented. The fiber optic backbone will continued to be deployed on ITS routes as needed and opportunities arise.

Deployment Schedule

Phase 3 deployment will occur in years 10-15, or beyond.

Deployment Costs

The three deployment phases previously defined establish a program for the inclusion of ITS in the regional transportation planning and funding process in Pima County. Estimation of general cost levels for each phase, particularly beyond a 5-year period, is spurious at best; yet it is necessary to provide a basis for comparison of ITS with alternate transportation infrastructure improvements. Costs for each deployment phase were estimated based on reasonable assumptions on number of field devices deployed and level of communications infrastructure achieved (WAN), and on current general costs associated with each item. The cost breakdown includes:

- Capital cost (estimated by unit) - cost for material procurement and installation
- Engineering cost (10% of capital and installation) - includes cost of analysis, design, system integration, and testing of the systems and subsystems.
- Software development costs - includes cost of design, coding, integration, and testing of the system software.
- Annual operations and maintenance costs (5-12 % of capital and installation) - includes the cost for operator and maintenance labor, operating expenses, and repair and replacement of equipment.

The estimated costs for each phase are summarized in Table 4.4. A 15% contingency is added to each phase to account for uncertainties associated with cost estimates at this phase of system planning. More detailed cost estimates for each phase are provided in Tables 4.5 through 4. 7.

Table 4.4
PAG Region ITS Deployment Costs

Element	Implementation Cost ($) Capital	Engineering	Software	Total	Annual O & M Cost
Freeway Management System	2,994,500	313,000	365,000	3,672,500	225,100
Arterial Management System	1,172,000	141,000	107,500	1,420,500	135,300
Transit Management System	Funded and currently being implemented.				
TMC Communications Links	525,000	52,500	-	577,500	45,750
Regional Traveler Information Center	450,000	175,000	25,000	650,000	65,000
Subtotal	5,141,500	681,500	497,500	6,320,500	471,150
15% contingency	771,225	102,225	74,625	948,075	72,150
Total Phase 1 Deployment Cost	**5,912,725**	**783,725**	**572,125**	**7,268,575**	**543,300**
Freeway Management System	4,820,000	528,500	157,500	5,506,000	323,500
Arterial Management System	2,005,000	219,500	57,500	2,282,000	193,900
Transit Management System	1,129,500	136,500	200,000	1,466,000	110,800
Wide Area Communications Network	2,600,000	260,000	-	2,860,000	142,000
Regional Traveler Information Center	50,000	5,000	250,000	305,000	30,000
Subtotal	10,604,500	1,149,500	665,000	12,419,000	800,200
15% contingency	1,590,675	172,425	99,750	1,862,850	118,613
Total Phase 2 Deployment Cost	**12,195,175**	**1,321,925**	**764,750**	**14,281,850**	**918,813**
Freeway Management System	1,150,000	115,000	-	1,265,000	115,000
Arterial Management System	725,000	97,500	50,000	872,500	98,300
Wide Area Communications Network	2,600,000	260,000	-	2,860,000	142,000
Subtotal	4,475,000	472,500	50,000	4,997,500	355,300
15% contingency	671,250	70,875	7,500	749,625	50,145
Total Phase 3 Deployment Cost	**5,146,250**	**543,375**	**57,500**	**5,747,125**	**405,445**
Total ITS Deployment Cost	23,254,150	2,649,025	1,394,375	27,297,550	1,846,958

Table 4.5
Phase 1 Estimated Deployment Costs

Element	Description	Cost ($)					
		Capital Cost					Annual
		Quantity	Unit	Extension	Engineering	Software	O & M
Freeway Management System (12-miles on I-10)	Detector Station	24	25,000	600,000	60,000	Included	42,000
	CCTV	12	45,000	540,000	54,000	Included	37,800
	CMS	3	120,000	360,000	36,000	Included	25,200
	HAR	1	50,000	50,000	5,000	Included	3,500
	Upgrade interchange signal controller, detection, and communication	4	20.000	80,000	8,000	Included	5,600
	Fiber Optic Communications:						
	Fiber Backbone						
	Fiber backbone in existing/planned conduit	16 miles	50,000	800,000	50,000	-	56,000
	Fiber Link to ADOT District	2 miles	100,000	200,000	20,000	-	14,000
	Communications Hub (Field)	4	50,000	200,000	20,000	-	14,000
	Leased Communications	1 L.S.	-	-	-	-	10,000
	ADOT District TMC:						
	Central Server	2	50,000	100,000	10,000	100,000	10,000
	Workstation	2	25,000	50,000	Included	15,000	5,000
	Video Monitor	5	500	2,500	Included	Included	500
	Video CODEC	5	2,000	10,000	Included	Included	1,000
	Video Switching Equipment	2	1,000	2,000	Included	Included	500
	Data Manager Software	1 L.S.	-	-	-	250,000	Included
	Integration/Test	1 L.S.	-	-	50,000	-	-
	Sub-total			2,994,500	313,000	365,000	225,100
Arterial Management System (40 miles of Arterials)	Detector Station	12	5,000	60,000	6,000	Included	4,200
	Video-Image Detection System	23	30,000	690,000	69,000	Included	48,300
	CCTV	1	45,000	45,000	4,500	Included	4,500
	Upgrade intersection signal controller, detection, and communication	17	20,000	340,000	34,000	Included	23,800
	Leased Communications	1 L.S.	-	-	-	-	50,000
	Tucson TMC Upgrade:						
	Workstation	1	25,000	25,000	2,500	7,500	2,500
	Video Monitor	4	500	2,000	Included	Included	500
	Video CODEC	4	2,000	8,000	Included	Included	1,000
	Video Switching Equipment	2	1,000	2,000	Included	Included	500
	Data Manager Software	1 L.S.	-	-	-	100,000	Included
	Integration/Test	1 L.S.	-	-	25.000	-	-
	Sub-total			1,172,000	141,000	107,500	135,300

Table 4.5 (cont.)
Phase 1 Estimated Deployment Costs

Element	Description	Cost ($)					
		Capital Cost			Engineering	Software	Annual O & M
		Quantity	Unit	Extension			
Transit Management System	Transit AVL System	Currently being implemented.					
TMC Communications Links (Tucson, ADOT District, Sun Tran/Van Tran)	Fiber Optic Cable	3 miles	100,000	300,000	30,000	-	15,000
	TMC Communications Hubs	3	75,000	225,000	22,500	Included	15,750
	Leased Communications (other agency links)	1 L.S.	-	-	-	-	15,000
	Sub-total			525,000	52,500	-	45,750
Regional Traveler Information Center	Traveler Information Database	1 L.S.	-	-	150,000	25,000	20,000
	Central Server	1	50,000	50,000	Included	Included	5,000
	Cable TV Server	1	50,000	50,000	Included	Included	5,000
	Bulletin Board Server/Internet Page	1	50,000	50,000	Included	Included	5,000
	Traveler Advisory Telephone	1	100,000	100,000	Included	Included	10,000
	Public Kiosks	4	50,000	200,000	Included	Included	20,000
	Private Kiosks	Privately Funded					
	Integration/Test	1 L.S.	-	-	25,000	-	-
	Sub-total			450,000	175,000	25,000	65,000

Table 4.6
Phase 2 Estimated Deployment Costs

Element	Description	Cost ($)					
		Capital Cost					Annual
		Quantity	Unit	Extension	Engineering	Software	O & M
Freeway Management System (11-miles on I-10 and I-19)	Detector Station	22	25,000	550,000	55,000	Included	60,000
	CCTV	9	45,000	405,000	40,500	Included	40,000
	CMS	2	120,000	240,000	24,000	Included	36,000
	Ramp Meters	32	10,000	320,000	32,000	Included	5,000
	Upgrade interchange controller, detection, and communications	10	20,000	200,000	20,000	Included	14,000
	Weigh-In Motion Station	2	135,000	270,000	27,000	Included	27,000
	Fiber Optic Communications:						
	Fiber Backbone						
	Fiber backbone in existing/planned conduit	8 miles	50,000	400,000	40,000	-	2,000
	Fiber backbone in new conduit	22 miles	100,000	2,200,000	220,000	-	110,000
	Communications Hub	3	50,000	150,000	15,000	-	15,000
	ADOT District TMC:						
	Central Server Upgrade	1 L.S.	-	-	5,000	50,000	5,000
	Workstation	1	25,000	25,000	Included	7,500	2,500
	Video Wall Display	1	10,000	10,000	Included	Included	1,000
	Data Manager Software	1 L.S.	-	-	-	100,000	Included
	Integration/Test	1 L.S.	-	-	50,000	-	-
	Intelligent Gateway	1	50,000	50,000	Included	Included	6,000
	Sub-total			**4,820,000**	**528,500**	**157,500**	**323,500**
Arterial Management System (41.5 miles of Arterials)	Detector Station	20	5,000	100,000	10,000	Included	7,000
	Video-Image Detection System	22	30,000	660,000	66,000	Included	46,200
	CCTV	8	45,000	360,000	36,000	Included	25,200
	CMS	6	120,000	720,000	72,000	Included	50,400
	Upgrade interchange controller, detection, and communications	4	20,000	80,000	8,000	Included	5,600
	Leased Communications	1 L.S.	-	-	-	-	50,000
	Tucson TMC Upgrade:						
	Workstation	1	25,000	25,000	2,500	7,500	2,500
	Video Wall Display	1	10,000	10,000	Included	Included	1,000
	Data Manager Software	1 L.S.	-	-	-	50,000	Included
	Integration/Test	1 L.S.	-	-	25,000	-	-
	Intelligent Gateway	1	50,000	50,000	Included	Included	6,000
	Sub-total			**2,005,000**	**219,500**	**57,500**	**193,900**

6/10/96

Table 4.6 (cont.)
Phase 2 Estimated Deployment Costs

Element	Description	Cost ($)					
		Capital Cost			Engineering	Software	Annual O & M
		Quantity	Unit	Extension			
Transit Management System	Transit TMC Upgrade:						
	Workstation	1	25,000	25,000	2,500	Included	2,500
	Video Monitor	5	500	2,500	Included	Included	500
	Video CODEC	5	2,000	10,000	Included	Included	1,000
	Video Switch	2	1,000	2,000	Included	Included	500
	Software	1 L.S.	-	-	-	200,000	Included
	Integration/Test	1 L.S.	-	-	25,000	-	-
	Radio/AVL Equipment	50	7,000	350,000	35,000	Included	35,000
	CCTV at Transit Centers	3	30,000	90,000	9,000	Included	6,300
	Microwave (communications with Transit Centers)	3	50,000	150,000	15,000	-	15,000
	Electronic Fare Payment Equipment	100	5.000	500,000	50,000	Included	50,000
	Sub-total			1,129,500	136,500	200,000	110,800
Expand Wide-Area Communications Network	Fiber Optic Cable	20 miles	100,000	2,000,000	200,000	-	100,000
	Upgrade TMC Communications Hubs (SONET)	3	200,000	600,000	60,000	Included	42,000
	Sub-total			2,600,000	260,000	-	142,000
Regional Traveler Information Center	Upgrade Traveler Information Database	1 L.S.	-	-	-	100,000	10,000
	Private Kiosks	Privately Funded					
	Interactive Rideshare System	1 L.S.	50,000	50,000	5,000	150,000	20,000
	Radio Broadcast Data System (RBDS)	Privately Funded					
	Sub-total			50,000	5,000	250,000	30,000

Table 4.7
Phase 3 Estimated Deployment Costs

Element	Description	Cost ($)					
		Capital Cost					Annual
		Quantity	Unit	Extension	Engineering	Software	O & M
Freeway Management System	Detector Station	46	25,000	1,150,000	115,000	Included	115,000
	Sub-total			1,150,000	115,000	-	115,000
Arterial Management System (24 miles of Arterials)	Detector Station	12	5,000	60,000	6,000	Included	4,200
	Video-Image Detection System	12	30,000	360,000	36,000	Included	36,000
	CCTV	5	45,000	225,000	22,500	Included	22,500
	Upgrade interchange controller, detection, and communications	4	20,000	80,000	8,000	Included	5,600
	Leased Communications	1 L.S.	-	-	-	-	30,000
	Tucson TMC Upgrade:						
	Data Manager Software	1 L.S.	-	-	-	50,000	Included
	Integration/Test	1 L.S.	-	-	25,000	-	-
	Sub-total			725,000	97,500	50,000	98,300
Expand Wide-Area Communications Network	Fiber Optic Cable	20 miles	100,000	2,000,000	200,000	-	100,000
	SONET Hubs (Field)	6	50,000	300,000	30,000	Included	21,000
	SONET Hub (TMC)	3	100,000	300,000	30,000	Included	21,000
	Sub-total			2,600,000	260,000	-	142,000
Regional Traveler Information Center	Private Kiosks	Privately Funded					
	In-Vehicle Navigation Interface	Privately Funded					
	Sub-total			-	-	-	-

4.5 Expected ITS Benefits

Existing intelligent transportation systems have proven to be beneficial both to users and providers of surface transportation. Based on the experience of other metropolitan areas around the country, the FAG Region can expect to experience similar benefits from the implementation of **ITS.** Following is a discussion of the benefits that have been found to be associated with deployment of the ITS core elements and to what level these benefits are expected to be achieved in the PAG Region based on the recommended deployment plan.

Freeway Management Systems

Metropolitan areas that have deployed advanced monitoring, control, and motorist information systems on freeway corridors have realized significant improvement in overall corridor traffic flow, including reduced travel time and delay, and increased utilization of available corridor capacity. For example, in Minneapolis, after 10 years of operation, studies show that average freeway speeds during commute periods increased from 34 to 46 mph, even though traffic volumes on the freeways increased by nearly one-third.

In Pima County, travel demand on the l-10 and l-19 freeways is expected to increase dramatically over the next 20 years. Even with major freeway corridor improvements programmed for implementation over the next 10-15 years, significant congestion is expected over the long term. In the near term, ongoing freeway corridor construction projects will likely result in increased delays due to construction activities as well as possible increases in accidents, Deployment of ramp metering, traffic monitoring, and traveler information systems will result in improved freeway operation, possibly allowing for the deferment of continued capital expenditures to increase corridor capacity. The level of benefits which will likely be achieved will depend upon the degree of congestion which occurs.

Traffic Signal Systems

Benefits associated with the installation of higher levels of traffic signal system integration and control are well documented. Statewide traffic signal system implementation programs in California and Texas have reported that benefit/cost ratios as high as 60:1 have been achieved by installing time-based coordination or interconnecting arterial signals into a centrally monitored and controlled system.

Deployment of centralized control systems provide jurisdictions with greater flexibility to adjust signal timing in response to unexpected shifts in travel demand patterns. A centralized signal system also provides continuous monitoring of signal control equipment and failure reporting, reducing maintenance costs and improving system reliability. Thus, not only does deployment of advanced traffic signal control provide the means to improve arterial traffic flow benefiting the traveler, it also reduces traffic signal maintenance costs and provides ancillary air-quality benefits.

Considering that the majority of traffic signals in metropolitan Pima County are already under centralized control, significant benefits have already been realized. However, additional benefits can be achieved through continued expansion of the system, and utilization of the system to monitor traffic conditions and verify incidents. Deployment of advanced detection systems also provides the opportunity for implementation of traffic adaptive signal control methods, which actually adjust signal timing based on actual traffic demand. Several traffic adaptive systems have been operating in Detroit and Toronto and report that travel times have decreased nearly 6 percent.

Incident Management Systems

Incident management systems have been in place on freeway corridors around the country for many years and have proven to be highly beneficial. The deployment of surveillance cameras, motorist information systems, service patrols, and incident management teams in many urban areas around the country have resulted in reduced incident response times, which translates into fewer delays for travelers and less chance of fatality to accident victims. In Minnesota, a program to assist disabled vehicles on urban freeways has reduced the duration of breakdowns by 8 minutes, Since disabled vehicles represent 85% of service calls, the impacts of programs which reduce detection, clearance, and response times are highly beneficial and have a high level of public acceptance. Improved incident management capabilities have proven to be particularly valuable on corridors undergoing lengthy construction projects.

Although it is difficult to estimate the potential benefits ITS will have on incident management in the PAG Region, reductions in incident related delay will likely be realized on heavily traveled, controlled access, routes where opportunities for diversion from the route are limited. During construction, traffic monitoring and traveler information systems are expected to benefit both the freeway motorist as well as the ADOT and the Department of Public Safety.

Multimodal Traveler Information Systems

The benefits of dissemination of traffic, transit, and roadway conditions information to travelers, both en-route and pre-trip, will become increasingly beneficial in Pima County as traffic demand and congestion levels increase. As the roadway network becomes more congested, travelers will need and want to become more aware of how conditions are changing. A traveler information system is considered a necessary complement to freeway and arterial management systems, the transit management system, and incident management programs.

Surveys performed in the Seattle and Boston metro areas indicate that 30-40% of travelers frequently adjust travel patterns based on travel information. Traveler information systems are showing increased popularity and usage. An automated transit information system in Rochester, New York, resulted in an increase in calling volume of 80%. In 1995, the Boston SmarTraveler system received nearly 250,000 calls per month.

Transit Management Systems

The transit management system which is currently being implemented on the Sun Tran and Van Tran fleets will provide benefits to both users and providers of the system. Depending upon the level of system deployment, on-time performance will improve; however, perhaps the greatest benefit of this system will be in reduced maintenance and operating costs of these transit fleets.

Automatic Vehicle Location (AVL) systems have been shown to directly improve transit schedule adherence. Transit systems in Baltimore, Kansas City, Portland, and Milwaukee have realized improved on-time performance ranging from 5 to 23 percent. The Kansas City Transportation Authority reported an annual operating expense reduction of $0.5 million on a $1.1 million investment. Other transit systems have reported reductions in fleet size by 2 to 5 percent due to increased efficiencies in bus utilization.

Electronic Fare Payment

Although it is unclear whether use of electronic fare payment on SunTran/VanTran will increase ridership, it is likely that the real benefits realized will be in savings attributed to more efficient fare collection procedures.

4.6 Complementary ITS Activities

This section discusses activities that can enhance ITS projects. Activities that enhance ITS can be classified as education, travel demand management, traditional traffic engineering measures, and Incident Management Teams.

4.6.1 Education

ITS represents a significant shift away from conventional transportation, to an interactive and responsive system, wherein travel is integrated through accurate and timely dissemination of information. Successful implementation of ITS requires participation of travelers, therefore it is necessary to consider education or creation of public awareness and understanding of ITS activities being conducted in conjunction with ITS projects that can enhance ITS system efficacy.

A marketing/education program that explains to travelers how to use system components, the direct benefits of ITS, and even what enhancements they might anticipate, will accelerate public acceptance for ITS projects in the region. This program may include Public Service Announcement (PSAs) on radio and television, newspaper advertising and similar traditional public relations techniques. Outreach activities directed toward major employers, such as that conducted through the PAG Rideshare program, can be highly effective in reaching a diverse audience. PAGTPD will serve as a point-of-contact for information regarding ITS activities undertaken by jurisdictions throughout the region.

Public education need not be linked to specific projects, although that may occur as specific ITS projects come on-line. Continuing education will be required to acclimate the public to the ITS paradigm, beginning with guidance about how to use and benefit from advanced features of the existing transportation system. There is a general misconception, for example, that the present traffic signal system should be able to provide favorable signal timings at all intersections for all directions of travel. Education is required to convey to the public an understanding that the system is programmed to create priority *corridors,* and that at certain times of the day, signal timing favors certain directions of travel. The lack of awareness of benefits of the traffic signal system is instructive as to how misconceptions might detract from successful implementation of a ITS projects.

4.6.2 Travel Demand Management (TDM)

The goal of Travel Demand Management is, broadly speaking, identical to that of ITS: optimum use of the transportation system. In order to meet federal requirements for developing a Congestion Management System, PAG conducted the Mobility Management Study and produced the Mobility Management Program (MMP). This program inventories and assesses numerous TDM strategies, Traffic Control Measures (TCMs) and Transportation Systems Management (TSM).

As the following examples illustrate, advanced transportation technologies (ITS) can readily enhance TDM strategies. ITS can assist in ride-sharing by providing ride matching more conveniently even on a real-time basis. Advanced communications and Automatic Vehicle Location (AVL) technology makes possible personalized public transportation, where smaller transit vehicles are enabled to deviate from fixed route service to provide personalized service. (This service is frequently referred to as Dial-A-Ride service.) With Electronic Fare Payment Systems employers will be more likely to subsidize transit usage, because they will be charged only for rides that employees take. Finally, a wide range of advanced communications technologies encourages telecommuting, which would cut down on travel between home and office.

4.6.3 Traditional Traffic Engineering Measures

Within the traffic engineer’s toolbox for alleviating congestion are “traditional” traffic engineering measures. They include the continued expansion of the existing traffic-signal system, and upgrading of signal timing programs. Also included is more extensive use of priority corridors, in conjunction with education as to how to use the priority-corridor system. An ITS arterial management system is enhanced by effective use of priority corridors, providing good north-south and east-west coverage, along with access to traveler information.

Disallowing left turns on certain corridors during peak hours is an option that would permit redistribution of crucial seconds to the through movement that is experiencing high demand for green time , thereby optimizing the signal cycle for peak-hour travel needs (i.e., commute trips). Precedent for use of this strategy in the region is seen in the reversible-lane corridors, where left turns are eliminated completely during peak hours. Possible objections from the public for this strategy might be overcome through education regarding ITS benefits. Short of complete elimination, protected left-turn phases can be removed, yet still allowing left-turns during the permitted phase.

Conventional traffic engineering wisdom has long held that drivers will reject one-way pairs spaced a distance greater than 600 feet. Longer commutes common today warrant revisiting that idea. One-way roadway pairs spaced at distances of one-quarter to one-half mile may be feasible, as drivers may not object to going the extra distance to take advantage of the increased capacity and efficiency of a one-way route. A system with one-way pairs can be implemented with or without an ITS arterial management system.

4.64 Incident Management Teams

Incident Management systems have been in place on freeway corridors around the country for many years and have proved to be highly beneficial. The deployment of ITS features such as surveillance cameras, traveler information systems, service patrols and incident management teams can significantly increase the benefits of an incident management program, however, an effective system of coordinated incident management need not be ITS related.

In Maricopa County, ADOT and the Department of Public Safety has developed a freeway management program called ALERT, which includes teams organized to manage incidents on freeways and development of emergency route plans. Emergency route plans have been prepared for freeways in the PAG region, but as yet, incident management teams have not been formally organized.

Incident Detection and Management is a Transportation System Management technique identified in the PAG Mobility Management Plan. PAG in the FY 97 Overall Work Program has identified the need to provide resources to begin the process of facilitating interjurisdictional incident management teams.

The benefit of incident management for the PAG region will likely be reductions in incident-related delay, particularly on heavily traveled, controlled-access routes (i.e., freeways) where opportunities for diversion from the route are limited.

CHAPTER 5. FUNDING

5.1 Introduction

Identification of realistic fund sources and levels of funding is a crucial aspect of the Strategic Deployment Plan because projects identified in the previous chapter are dependent on the adequate and timely availability of financial resources. Clearly, the funding of ITS projects in the Tucson area is problematic and a great deal of aggressive, creative and cooperative effort will be required to achieve success. With respect to public moneys, ITS candidate projects must, in general, follow the same analytical prioritization process as other projects so as to establish their relative benefits in relation to the costs shown. However, there seems to be emerging recognition that ITS projects, by their very nature, are excellent investments of public funds. While several federal, state and local transportation funding programs are potentially available to implement ITS projects, it is clear that funding must also be sought and obtained from the private sector. At the recent ITS America conference in Houston, professionals knowledgeable about ITS funding estimated that up to 80 percent of ITS resources ultimately will have to be generated privately if ITS in general is to be successful.

The fund sources that must be pursued to successfully implement the Strategic Deployment Plan must also be available at specified periods consistent with the short, medium and long term project phasing. Fund sources, amounts, restrictions on use, period of availability, and competition among traditional transportation programs will determine if the identified ITS projects can be implemented. Detailed information concerning the specifics of ITS funding opportunities, processes and challenges can be found in the Funding Options Technical Memorandum.

5.2 ISTEA Funding Opportunities

ISTEA legislation provides funding for several highway system(s) classifications; among them are: the National Highway System (NHS), the Interstate System and the Surface Transportation Program (STP). The NHS is the core highway system of the nation and is made up of those facilities considered important to interstate travel, national defense, and otherwise provide connections to other modes of transportation considered essential for national economic development. The STP is applicable to roadways functionally classified as arterials, but not rural minor collectors or local streets. ISTEA funding for all of these classifications is limited; however, despite these limitations, the legislation provides a great deal of flexibility so that transportation improvements preferred by local governments can be implemented. Funding for ITS projects can be obtained directly from the traditional programs such as NHS, Interstate Maintenance, Bridge Rehabilitation and Replacement, and those administered by the Federal Transit Administration, as long as the specified usage restrictions are adhered to. Alternatively, funds can be transferred among categories.

Many ITS programs and projects around the nation utilize Congestion Mitigation Air Quality (CMAQ) funds; however, Tucson has been determined not to be eligible for these moneys. Other ISTEA funding programs, such as Highway Safety, can be used for safety related ITS projects; even Highway Planning and Research moneys can be used to underwrite research and development for ITS. For a discussion of the funding restrictions discussed above, refer to the Funding Options Technical Memorandum.

Several non-transportation fund sources within ISTEA also may be able to provide funding for ITS through public-public and public-private partnerships, Public-public partnerships involve public agencies, some of which are transportation-oriented and others which are not. Funding for these arrangements may be available through the Innovative Projects Program of ISTEA. To obtain funding under this program, a project design must facilitate access to data needed to conduct a complete evaluation of the funded project.

In recognition of the ISTEA legislation, ADOT has established the Office of Privatization, which deals with public-private funding opportunities. Private entrepreneurs are expected to show interest in participating in ITS projects because they anticipate a reasonable return on their investments. A list of organizations with whom such partnerships might be created is contained in the Funding Options Technical Memorandum.

5.3 USDOT Initiatives

In recognition of the potentially enormous benefits and opportunities to achieve transportation system efficiencies associated with ITS technologies, as well as to stimulate the large private investment requisite to achieve those efficiencies, the USDOT is encouraging federal, state and local government investment in development of a core Intelligent Transportation Infrastructure (ITI). Well targeted public and private investment, stimulated by federal leadership and financial seed money, will bring about the realization of ITI. It has been estimated that every dollar of public sector funds stimulates a private sector investment of between four and five dollars.

ITS early deployment studies are intended to develop a road map for deployment of the most cost effective and efficient operational ITS features for alleviating congestion and improving safety in metropolitan areas. It is intended that ITI will build upon existing ITS hardware, software, communications links, and institutional arrangements.

Transportation Secretary Frederico Pefia has strongly encouraged metropolitan areas to invest in ITI. The eight components of ITI that have been identified are: traffic signal control systems, freeway management systems, transit management systems, incident management programs, traveler information centers, electronic fare payment, electronic toll collection, and improved safety at railroad grade crossings.

To stimulate the required investment, the USDOT recently solicited and received model deployment proposals for urban areas. Resulting grants will be for up to $10 million with an additional $10 million required of successful applicants in public-private matching funds. Secretary Pena already has announced his intent to propose similar incentives for creating ITS infrastructure in rural areas and for commercial vehicle operations.

Savings in the implementation of ITI can be expected by building upon the existing ITS systems and by implementing policies that encourage maintenance to include retrofitting existing systems with advanced technologies. The efficiencies of this type of investment would be very beneficial to Tucson because 70 percent of public transportation funds must be allocated to operating and maintaining the existing system. Accomplishment of a seamless and sophisticated ITI can be achieved over the long term if well thought out maintenance policies are adopted throughout the region. The greatest challenge to the extraordinary interagency cooperation and enthusiasm for ITS in the Tucson area will be in working together selflessly to develop a realistic and achievable financial game plan that will make ITS a reality.

5.4 Potentially Available ITS Resources

The Tucson metropolitan area receives approximately $600 million in federal, state and local transportation dollars over a five-year period, or an average of $120 million annually.

While a detailed discussion of funding eligibility, sources and amounts is contained in the Funding Options Technical Memorandum, the Table 6.1 below summarizes the breakdown of the $600 million by source between fiscal years 1996 and 2000. For the most part, the ITS projects proposed in the previous chapter are eligible for these resources at the discretion of federal, state and local government.

Table 5.1

Summary of Transportation Funds For Pima County

FY 1996-2000

(1995 dollars in millions) 30-Nov-95

	1996	1997	1998	1999	2000	Total
Federal	83.58	49.419	56.733	69.313	71.045	330.09
State	5.395	9.672	4.046	4.717	2.845	26.675
Local	70.332	43.384	41.025	41.359	43.411	239.511
Total	159.307	102.475	101.804	115.389	117.301	596.276

Federal funds are available via the ISTEA legislation and other federal transportation programs annually. The Administration and the Congress authorized $110 million for ITS funding in federal FY 1996-97, with an additional $113 million authorized through ISTEA. However, most ITS moneys have been earmarked for special projects or for ITS programs not applicable to the Tucson area.

State transportation moneys are provided through the Highway User Revenue Fund (HURF) and Local Transportation Assistance Fund (LTAF) programs; the latter is financed from lottery proceeds. About $65 million in HURF moneys are allocated annually within Pima County for programming by the local jurisdictions. In addition, the State Transportation Board has programmed about $4.3 million in HURF funds over the next 5 years for transportation projects on state highways in the region. However, programming the HURF moneys referred to as “15 percent HURF" (conservatively estimated at $12 million each of the next five years) is the domain of PAG. LTAF resources are rather limited (about $3 million is available annually to local jurisdictions other than Pima County) and are programmed directly by local jurisdictions.

Local revenues available for transportation are, in effect, distributions of HURF. LTAF, local property taxes and miscellaneous fees allocated to jurisdictions within the region. The term local is used in the context that these moneys are generated from local revenues or are available for use on transportation capital, operating or maintenance projects at local discretion.

A key to the availability of these combined revenues for ITS projects is the decision process(es) established to evaluate the potential benefits (usually in relation to costs) of capital projects. As an aside, it is important to keep in mind that life cycle costs are used in making these evaluations. PAG has established a comprehensive process for equitably judging locally proposed projects. A large proportion of the evaluation parameters account for the efficacy of ITS project characteristics. Once a program of projects is selected locally, and ratified by the PAG Regional Council, its component projects that are competing against other jurisdictions must be determined to be consistent with the evaluation parameters at the state level and be included on the State Transportation Improvement Program (STIP). Finally, all federally funded projects are subject to FHWA concurrence, including those ITS projects competing for ITS federal funding.

Studies performed nationally show that ITS projects yield substantial travel benefits, however very little hard data are available locally at this point in the implementation of ITS. Hence, the projects proposed for early deployment (within five years) will most likely be underwritten only if the principals of the agencies accept that ITS projects inherently provide a good return on each transportation dollar invested in the area. The ITS projects proposed for the Tucson region are not expensive compared to similar operations elsewhere in the country. Extensive ITS infrastructure already is in place in the Tucson region, thus ensuring an even greater marginal return for transportation dollars. Finally, it is universally accepted that unlimited traditional widening to increase capacity is not affordable and they are generally unacceptable to the public in terms of their other costs. ITS projects offer a unique opportunity to defer large amounts of capital investment. The time value of that deferred investment offers yet another benefit of ITS projects.

Chapter 6. ACTION PLANNING PHASE

6.1 Introduction

The Strategic Deployment Plan (SDP) is not an end unto itself; rather, it is simply a snapshot of an ongoing process leading to the ultimate implementation of ITS projects in the greater Tucson metropolitan area. There is a *continuing* need to carry out the myriad activities either specified or implied in the document. In other words, the SDP should be viewed as a living document.

Following issuance and approval of the SDP, a two-year period has been designated as the Action Plan phase. It is important that this phase of improving upon, and supplementing, existing ITS components be formalized. Were it not, the existing momentum and enthusiasm that currently characterizes **ITS** opportunities might well dissipate; the substantial and creative work accomplished to date as reflected in the SDP might well end up "on the shelf" without ever seeing the light of day.

6.2 Participants

Many local agencies and private citizens contributed a great deal to development of the ITS recommendations contained in the SDP. It is essential that these same agencies and citizens continue their thoughtful participation throughout the Action Plan phase. By consensus, PAGTPD will continue the lead role as "champion" to assure that the recommendations come to fruition. The City of Tucson, Pima County, the Arizona Department of Transportation and the Federal Highway Administration all will continue to have key responsibilities. No less important will be the continuing involvement of area citizens, a number of whom already have contributed formally through the User Services/Options Citizens' Advisory Committee (CAC) and TCOM 2000 Technical Advisory Committee (TAC). The Tucson area is fortunate in that a great deal of cooperation and mutual support already exists among the agencies having a key role in ITS project implementation.

Many policy, administrative, and technical issues will, of course, arise and must be resolved during this initial two-year effort to "bring on line" the projects identified for early deployment. Thus, there will exist an ongoing need for technical analysis, oversight, as well as an understanding and appreciation of community acceptance of ITS projects. During the formal study process culminating in the issuance and approval of the SDP, these functions were the respective responsibility of the Technical Advisory Committee (TAC), the Study Advisory Committee (SAC), and the CAC. These organizational structures will be retained throughout the Action Planning phase, although perhaps somewhat modified. For example, in consideration of the need to attract private sector investment , it would seem appropriate to invite private sector representation on the SAC. Particularly in light of the recommended FMS , the ADOT District Office should also be represented on this policy body.

6.3 Activities

A great number of disparate activities will be carried out by the participants during the two year Action Planning phase of the SDP. These activities are best distributed among three categories: projects, funding, and organization.

- **Projects:** The primary objective is, of course, to bring each identified early deployment project to the threshold or, ideally, beyond the threshold of implementation. During this period Requests for Proposals (RFPs) will be developed and issued for the detailed design of each project. Subsequently, project designs will be initiated and completed. For each project a detailed operations plan will be prepared spelling out agency responsibilities, operation and maintenance protocols, coordination with other ITS projects, evaluation parameters, and other information that will assure the project's ultimate success. Moreover, the long-term projects will benefit from a process of successive refinement, eventually leading to their implementation during the outlying years. Within this same time frame efforts will be made to assure availability of the requisite communications architecture elements to support the projects. Finally, a continual awareness will exist for opportunities to define, evaluate, design and implement cost effective ITS projects not identified in the SDP.
- **Funding:** While potential fund sources for early deployment projects are identified in Chapter 5 Funding, these projects will have to compete with non-ITS, or traditional, projects for funding via established priority programming methods. Also, it is possible that off-line, or non-competitive, fund sources will materialize to support these projects. In any event, a major activity of this phase will be to identify, justify, and secure sufficient funding to achieve project(s) design and implementation. It is essential to appreciate that operating and maintenance funding commitments will be every bit as important to obtain as are those for capital construction. A stable and mature funding stream will be developed consistent with the nature and potential benefits of ITS projects. Financial team building will be an important activity of the participants, particularly the SAC. Finally, considering the anticipated difficulty of nailing down public funds, every effort will be made to secure private sector investment to leverage their effectiveness.

- **Organization:** The participants referred to earlier and the organizational arrangements within which they function will face a variety of responsibilities during the Action Plan phase of the project. Some of the recommended early deployment projects are multi-jurisdictional. Thus, organizational responsibilities will have to be spelled out for each project and embodied both in project operational plans and in intergovernmental agreements (IGAs). These IGAs will have to be ratified by each involved agency. Many administrative and institutional issues undoubtedly will arise. They may include, for example, matters of agency “ownership,” potential liability, data security, operational and maintenance roles, infrastructure prerequisites, and others. Of great importance will be the need to collect and analyze project(s) and system data to determine the efficiency and effectiveness of the implemented projects specifically and the ITS system in general. A public awareness and education effort with respect to ITS benefits and utility will have to be crafted. Agency representatives will have to provide for inclusion of operating and maintenance costs in their budgets once agreement has been reached on sharing of costs. Finally, and perhaps most importantly, all participants will have an ongoing responsibility to assure that the momentum of implementing ITS is maintained and that the SDP is periodically updated to reflect changing conditions.

CHAPTER 7 SUMMARY

This Strategic Deployment Plan is a comprehensive roadmap for development and implementation of Intelligent Transportation Systems **(ITS)** in the greater Tucson metropolitan area over the next fifteen years, with greatest emphasis and detail focused on early deployment within five years.

The underlying premise for the application and deployment of ITS technology is based on the general acknowledgment among transportation policy makers that continually growing demand for motor vehicle travel cannot always be met by provision of more roadway capacity. Rather, the realistic assessment of financial, environmental and political constraints should guide public policy response to increasing travel demand by making existing transportation systems operate more efficiently and effectively through the use of available and emerging technology.

The plan begins with a broad, yet comprehensive, overview of what ITS is and what benefits can be anticipated from its deployment; this is followed by a discussion of its national context and relevant underlying legislation.

The overall study leading to the project recommendations in this document was unique in that it was made up of two distinct components: a determination of what User Services are most appropriate for the Tucson area, and an analysis of what communications architecture best supports these User Services. The linkage among functional requirements, User Services and communications architectures is defined. The many existing and committed ITS projects in, and related to, the Tucson area also are cited. The study process, per se is documented extensively.

Local public agencies, the federal government, ADOT, the general public and the private sector are all stakeholders in the effective deployment of ITS. Chapter 3 contains a detailed description of their interrelationship during development of this Plan. But more to the point, the nature and timing of their interaction during the two year Action Planning phase following acceptance of the plan will vary considerably; thus, a good deal of thought has been given to the fact that organizational issues and challenges undoubtedly will arise dunng this period. Critical to successful implementation of ITS in this region will be continuation of the extraordinary cooperation and enthusiasm enjoyed among all parties so far.

An array of the most effective ITS projects for the Tucson area is presented in Chapter 4. Projects recommended for early deployment are defined to the extent that, pending availability of funds, they can proceed directly to the design process without additional definition or analysis. All of the recommended projects are a direct outgrowth of the open, highly participatory process that characterized the study, and represent a general consensus of what ITS applications are best suited for the region. Particular efforts were made to build upon the substantial “already in place” ITS infrastructure.

Funding for implementation of the recommended projects may be problematic. Chapter 5 contains an overview of federal, state and local fund eligibility for the recommended projects. Critical to this issue is that ITS projects are subject to the same programming criteria and priority analyses as are most other more traditional transportation projects. Notwithstanding the fact that little hard data exists concerning the benefits to be anticipated from the recommended ITS projects, the case will have to be made that these projects are relatively low cost and yield substantial benefits; hence, they are very cost-effective and offer the opportunity to defer for years projects costing tens of millions of dollars.

Finally, this document defines a two year Action Planning phase of ITS strategic deployment. It is a particularly important chapter because it itemizes many of anticipated activities and challenges that will face the participants, as well as the issues that must be dealt with if ITS is to be successfully deployed.

APPENDICES

Appendix A : List of User Services

The following table lists all 29 User Services. For convenience, they are “bundled” with User Services with which they will likely be deployed in combination. Some of them are self-explanatory. For a detailed description of each User Service, refer to the Appendix.

Table A.1 ITS User Services

Bundle	**User Services**
Travel and Transportation Management	1. En-route Driver Information 2. Route Guidance 3. Traveler Services Information 4. Traffic Control 5. Incident Management 6. Emissions Testing and Mitigation
Travel Demand Management	1. Demand Management and Operations 2. Pre-Trip Travel Information 3. Ride Matching and Reservation
Public Transportation Management	1. Public Transportation Management 2. En-Route Transit Information 3. Personalized Public Transit 4. Public Travel Security
Electronic Payment	1. Electronic Payment Services
Commercial Vehicle Operations	1. Commercial Vehicle Electronic Clearance 2. Automated Roadside Safety and Inspection 3. On-board Safety Monitoring 4. Hazardous Materials Incident Response 5. Commercial Vehicle Administrative Process 6. Freight Mobility
Emergency Management	1. Emergency Notification and Personal Security 2. Emergency Vehicle Management
Advanced Vehicle Control and Safety Systems	1. Longitudinal Collision Avoidance 2. Lateral Collision Avoidance 3. Intersection Collision Avoidance 4. Vision Enhancement for Crash Avoidance 5. Safety Readiness 6. Pre-Crash Restraint Deployment 7. Automated Highway System

APPENDIX B
TECHNICAL ADVISORY COMMITTEE MEMBERS

NAME	AFFILIATION
Larry Carpenter	Tucson Medical Center
Jim Cunningham	ADOT
John D'Andrea	Tucson Economic Development Corp.
David Denlinger	Arizona Department of Public Safety
Mark Dunbar	ADOT-Tucson District
Dick Guthrie	City of Tucson Dept. of Transportation
Ray Harwood	University Medical Center
Donald ljams	Tucson Police Department
Sheldon Jacobson	MCI
Patsy Joy	Sheriff's Department
Mike Leahey	Pima County Justice Courts
Bob Leone	Pima Community College
Jack Markle	Private Citizen
Bob Hunnicutt	City Information Services
Eric Nelson	Tucson Lightwave
Jim Perry	City of Tucson
Steve Peters	Community Info. &Telecommunications Alliance
John Powers	Pima County Information Services
Dan Roman	University of Arizona
Shalini Sen	PAG
John Carpenter	US West
Diahn Swartz	PAGTPD
Dave Wolfson	Pima County Department of Transportation

APPENDIX B (cont)

CITIZENS ADVISORY COMMITTEE (CAC)

Bodo Bartocha
Larry Barton
Jeremy Clifton
Judy Clinco
Arlan Colton
Marlis Davis
Philip Draper
Diana Edwards
Alan Kath
Arthur Keating
Dale Keyes
Pitu Mirchandani
Margaret Pellegrino
Larry Sakin
Jim Shea
David G. Smith
Paul C. Smith
Ron Stacey

Appendix C:
Phase 1 Deployment Project Descriptions:PAG REGION ITS PHASE 1 DEPLOYMENT

FREEWAY MANAGEMENT SYSTEM

Project Summary

The project will comprise installation of changeable message signing (CMS) , highway advisory radio (HAR), closed-circuit television cameras (CCTV) and vehicle detection stations along approximately 12 miles of I-10. The CMSs and HAR will provide motorists with real-time information on construction and incident-related roadway conditions. The field installation of CCTV cameras will allow each of two jurisdictions (Arizona Department of Transportation (ADOT) and City of Tucson to monitor critical locations along I-10 and at its interchanges with the arterial network. Finally, installation of strategically located vehicle detectors will supply the jurisdictions with additional traffic flow information which can be used to set control strategies and to provide input to CMS applications. The field hardware will be connected to a control center at the ADOT district office initially using leased communications. A dedicated fiber optic communications network will be implemented as frontage road construction along I-10 is completed.

Project Need

The principal purpose for this ITS project is to instrument the section of I-10 in metropolitan Pima County carrying the heaviest traffic flows in order to allow ADOT to better monitor and respond to traffic conditions. This capability is considered particularly important as reconstruction of I-10 will occur over the next 10-15 years, and efficient utilization of already limited freeway corridor capacity will be necessary. In addition, long term travel forecasts indicate that demand on I-10 will exceed capacity provided by planned corridor improvements.

Installation of CMS will provide ADOT with the means to disseminate traffic condition information to travelers on I-10. Also, the traffic condition information will be available to other travelers via a Regional Traveler Information Center.

Project Description

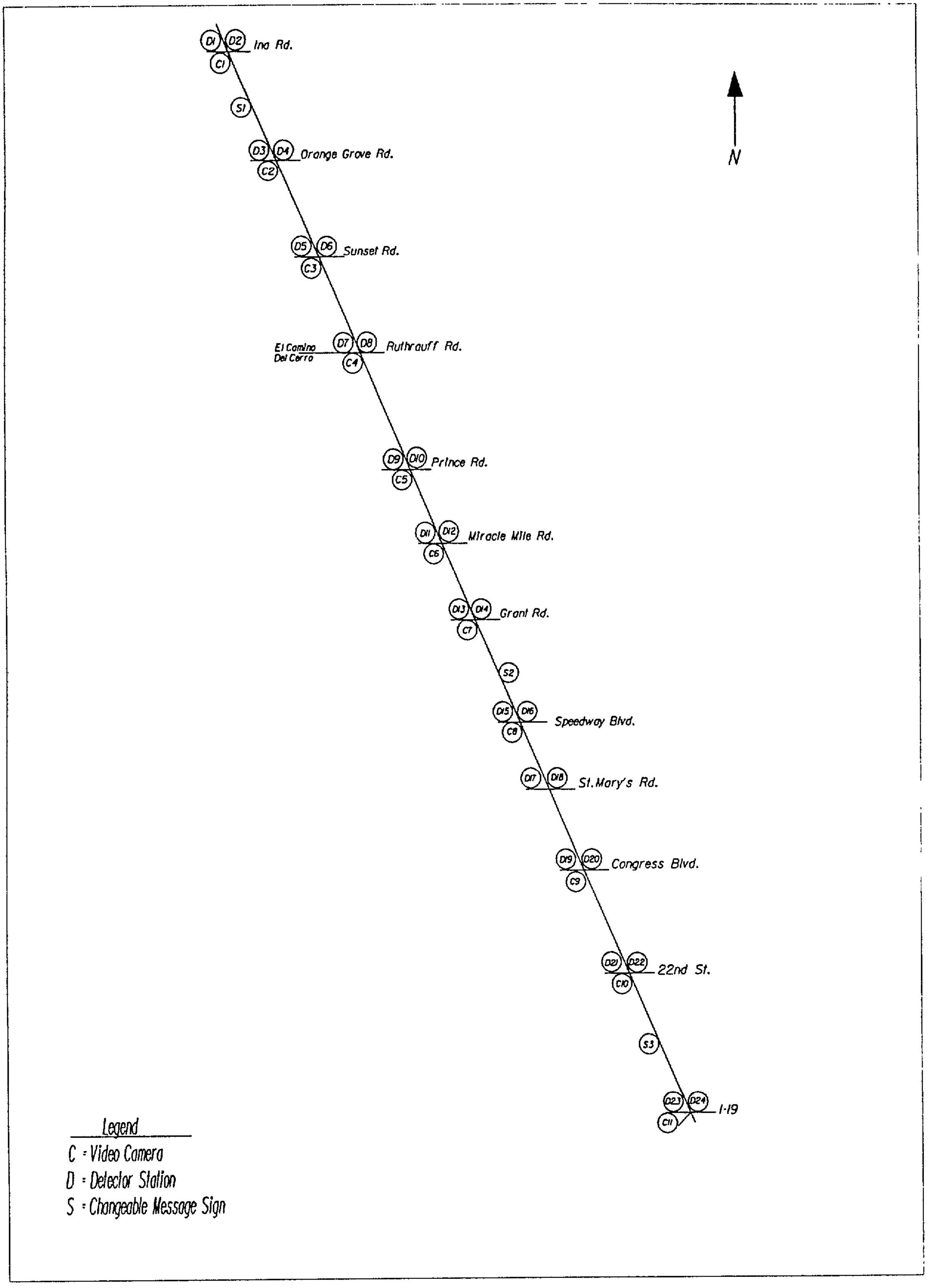
The project is located along Interstate 10, from Ina Road to Interstate 19, a total of about 12 miles. Included in the project is the installation of mainline vehicle detection using loop detectors. A total of approximately 24 detector stations (each station represents one direction of flow) will be constructed. Loop pairs will be placed in each through lane at each station. The loop configuration will allow both for vehicle counting and estimation of vehicle speeds. Generally, stations will be spaced at approximately one mile, and located in the vicinity of freeway interchanges. Specifications for location and construction details for the loop installations will be taken from the ADOT specifications established for the Freeway Management System in Maricopa County. Each detection station will be tied into a controller. Controllers will be located, to the extent possible, between the mainline and existing (or future) frontage roads, and as close as possible to the freeway on-ramp so that dual use of the control cabinet to house future ramp metering control hardware is facilitated.

A total of 12 video cameras are to be installed in this project. Fig. C.1 indicates the proposed location for the cameras. The video cameras will follow ADOT specifications, will be color, and will have the ability to provide surveillance across a 359-degree horizon with pan, tilt, and zoom functions. The location of each camera will be such that not only will the freeway be observable but also some observation on the adjacent arterials will be possible. It is anticipated that a fairly high mast design will be used so that the camera provides a wide view of the interchange area as well as a long view up and down the freeway itself. Cameras are spaced at approximately one mile.

Portable or temporary changeable message signs will be installed at 3 locations. At a future time, it is anticipated that additional CMS will be installed if the initial project is successful. These signs will be two-line, full matrix and will conform to ADOT standards and will be located at key decision points, as shown in Fig. C.1.

The long term goal for the communications element of this project includes the installation of fiber optic cable along at least one side of the freeway throughout the 12 mile section. Also, as part of the long term goal, a fiber optic cable will be installed, between the freeway at 22nd Street and the ADOT district office located near 22nd Street and 2nd Avenue. To ensure that an early start-up of operation is possible, it is recommended that the initial medium used for communications between the field and the ADOT district office be leased communications. ISDN service or T1 lines should be used to bring compressed video signals back to the district office. Dedicated data grade phone lines will provide necessary communications to detector station and CMS controllers.

The installation of a PC-based computer control center, with appropriate hardware and software to manage information flowing from the field detectors and video cameras, is to be installed at the ADOT district office. A direct tie-in using leased T1 lines between the ADOT district office and the statewide operations center in Maricopa County will be possible and would allow the statewide center to monitor traffic conditions during those hours when the local ADOT district office is not manned with operations personnel.



CEI Catalina Engineering, Inc.

FIGURE C.1
PAG ITS Strategic Deployment Plan
Freeway Management System - Initial Project

Project Tasks

The project phases and associated tasks are listed below.

Stage 1 - Design

Task 1	Prepare System Functional Design
Task 2	Compile ADOT Specifications for Detectors, CMS, and Video Cameras
Task 3	Compile ADOT Specifications for Control Center Hardware/Software.
Task 4	Prepare PS&E for Field Elements; CMS, CCTV, Loop Detectors
Task 5	Prepare PS&E and Work Statements for ADOT Control Center Elements

Stage 2 - System Installation

Task 8	Install and Test Field Hardware
Task 9	Install and Test ADOT Control Center Hardware
Task 10	Develop Control Center Software
Task 11	Integrate System Elements and Acceptance Test

Stage 3 - Project Assessment

Task 12	Perform Assessment of System Impacts

Project Schedule

The project duration is estimated to be 30 months, with all three phases being completed within that period. One constraint on completing the project within this schedule will be the type of solicitation and bid process used for the field elements. If such a process can be streamlined, the 30-month time estimate is achievable. If a longer solicitation process is required by the contracting agency or agencies, the project schedule may extend to 36 months.

Project Cost

The total cost for designing, installing, and assessing the initial components of the Freeway Management System is $2.382 million, based on use of leased communications for initial start-up. Installation of a fiber optic communications network along I-10, including a linkage with the ADOT district office is considered a design option. A breakdown of this cost is given below.

Project Cost

Phase 1 - Design	$223,000
Phase 2 - Implementation	

CMS - 3 at $120,000	360,000
HAR - 1 at $50,000	50,000
Video - 12 at $45,000	540,000
Detector Station - 24 at $25,000	600,000
Interchange Signal Controller (4 at $20,000)	80,000
District Control Center (Hardware/Software)	529,500
TOTAL	$2,382,500
Optional Fiber Optic Communications Network	$1,290,000
TOTAL FMS Cost with Fiber Optic Network	$3,672,500

PAG REGION ITS PHASE 1 DEPLOYMENT

ARTERIAL TRAFFIC MANAGEMENT SYSTEM

Project Summary

The project consists of the installation of loop and video-based vehicle detection systems at major intersections along four major arterial corridors in metropolitan Pima County. Also, upgrading of traffic signal controllers will be performed as needed along each of the four corridors. A control and communications link using fiber optic cable will be installed between the City of Tucson Traffic Management Center (TMC), the ADOT District Office, and the Price Service Center. Finally, the ability to communicate with traffic control devices in the field and to control these devices as appropriate will be installed in the form of hardware and software at the TMC. In essence, the project will result in a new level of monitoring major intersections and principal arterials to improve agency response to incidents and to provide visual information to the TMC and to other agencies for traffic control purposes.

Note that a fiber optic communications link between the TMC the ADOT District Office, and the Price Service Center will allow this project to be connected with the proposed Freeway Management System and the Sun Tran/Van Tran management center.

Project Need

The need for this project is based on the significantly increasing traffic volumes on the major arterial street system in the Tucson metropolitan area. Because the number of freeway lane miles is small in the region, both short and long trips are heavily oriented to the principal arterials. Traffic volumes in the range of 35,000 to 50,000 vehicles per day are commonly encountered on arterials which have four or six through travel lanes. There is a strong need to provide improved response to incidents along such heavily traveled arterials and to upgrade the vehicle detection systems and the traffic signal controllers so that the efficiency of these heavily loaded roadways can be maximized.

Project Description

The project is located along four of the metropolitan Pima County's most important arterials. A total of 34.5 miles of arterial centerline are included. Oracle Road, from Ina to Speedway (7 miles), Speedway Blvd., from Kolb to I-10 (8.3 miles), Broadway, from Kolb to I-10 (8.2 miles), and Ins/Skyline/Sunrise, from Swan to I-10 (11 miles) comprise the corridors of the proposed project. Along these four arterials, an inventory is to be established of vehicle detectors and traffic signal controllers that currently exist and any new upgraded equipment which is deemed essential for optimum operation will be identified. Upgrades of the controllers and any supporting hardware or detector systems will be accomplished during project implementation.

At 23 major intersections along the corridors, video-based vehicle detection systems will be installed. The video-based detection will provide the function of vehicle detection necessary for traffic signal operation and congestion monitoring as well as provide an ability to verify incidents at the intersections at which they are installed. In addition, system detector stations using loop detectors will be installed at 12 locations. These detector stations will be installed close to major intersections and will be tied into the signal controller. Fig.C.2 shows the locations where detection stations will be located on the four arterials. Seventeen signalized intersections which are not currently part of the City of Tucson central signal control system will be upgraded and integrated into that system.

In order to test the benefit and public acceptance of full-motion CCTV cameras on arterials, one camera will be installed at a suitable location, likely adjacent to a high traffic generator.

Communications between the TMC and field equipment will occur through dial-up leased telephone service (i.e ISDN) and leased data grade telephone circuits. Compressed video will be available to the TMC.

The project includes the installation of a dedicated fiber optic communications link between the TMC located in the County-City Public Works building, the City's

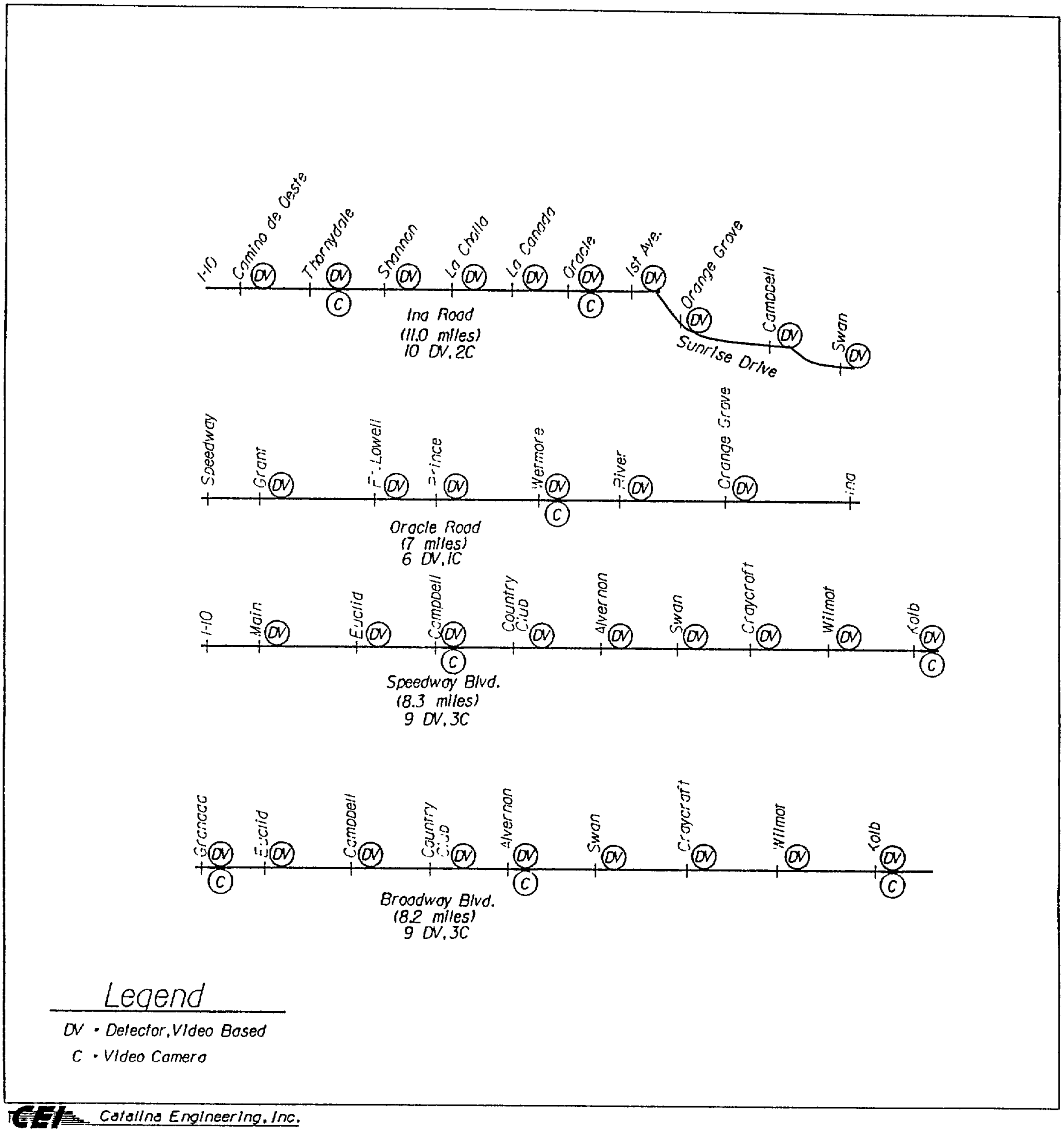


FIGURE C.2
PAG ITS Strategic Deployment Plan
Arterial Management System - Initial Project

Price Service Center located at South Park Ave and Ajo Way, and the ADOT District Office located at 22nd St. and 2nd Ave.

Installation of the control and communications hardware and software to manage the flow of traffic information and video will occur at the City's TMC.

For all of the above implementation, the current specifications of the City of Tucson will be used to acquire and install any new controllers which may be necessary, the video and loop-based detection systems, and the fiber optic communications link .

Since this project will involve deployment of ITS on roadways within four jurisdictions (Tucson, ADOT, Pima County, and Marana), inter-governmental agreements will be required to define operational procedures and responsibilities, and maintenance responsibilities. It is assumed that the system will be operated from the City of Tucson TMC and that appropriate communications links will be established with Marana and Pima County (a link with ADOT is already planned) to allow access to data and video

Project Tasks

The project phases and associated tasks are listed below.

Stage 1 - Design

Task 1	Prepare system functional design.
Task 2	Field review of sites for installation of video and loop detection systems, and identification of upgrades to signal hardware.
Task 3	Compile City of Tucson specifications for traffic signal controllers, loop detector upgrades, and video-based vehicle detection
Task 4	Develop specifications for Traffic Management Center hardware/software
Task 5	Prepare PS&E for field elements.
Task 6	Prepare PS&E and work statements for TMC hardware/software.
Task 7	Prepare PS&E for fiber optic communication link.

Stage 2 - System Installation

Task 8	Install and test field hardware
Task 9	Install fiber optic communications link
Task 10	Develop software.
Task 11	System integration and acceptance test.

Stage 3 - Project Assessment

Task 12	Perform assessment of system impacts

Project Schedule

The project duration is estimated to be 36 months. For Phase 1, approximately 12 months will be required, for Phase 2 approximately 18 months will be required, and for Phase 3 approximately 6 months will be needed to collect the appropriate assessment data.

Project Cost

The total cost for designing, installing, and assessing the arterial management system is $1.998 million. A breakdown of this cost is given below.

Project Cost

Stage 1 - Design	$166,000
Stage 2 - Implementation	
Video-based Detector Station (23 at $30,000)	**690,000**
CCTV (1 at $45,000)	***45,000***
Fiber optic communications link	***525,000***
Loop-based Detector Station (12 at $5,000)	***60,000***
Traffic Signal Controller Upgrades (17 at $20,000)	***340,000***
TMC Hardware/Software	172.000
TOTAL	$1,998,000

PAG REGION ITS PHASE 1 DEPLOYMENT

REGIONAL TRAVELER INFORMATION CENTER

Project Description

This project will result in the development of a central traveler information center which will house an information database for the multi-modal transportation system in the Pima County metropolitan area. The project will not only develop the hardware and software to manage the center but will also install various elements for distributing the information to the public. These distribution means will include information flow to cable TV stations, a transportation information bulletin board, and the establishment of public kiosks at selected locations. Also included will be the installation and operation of a traveler advisory telephone dial-in system.

Project Need

Currently, there exists no central point of information gathering and dissemination to provide travelers with traffic condition information for the Pima County metropolitan area. There does exist information which is presented on television and radio but only for very limited times during the peak travel periods. Also, there exists a dial-in ADOT statewide service which gives general conditions on the state highway system. However, there is no single service or agency in the metropolitan area which collects all available data on roadway and traffic conditions, flooding conditions, on-going and planned construction and maintenance schedules, transit schedules, and rideshare information, and which disseminates that back through various media to the public.

What is needed is a unified system for ensuring that travelers in the system, regardless of mode, will have readily accessible and up-to-date data both for pre-trip planning and for en-route decision making.

Project Description

The cornerstone of this project will be the development of a database which can accumulate, summarize, and disseminate information on traffic conditions along the freeway and major arterial roadways which are being operated as management systems. The Phase 1 Freeway Management System and Arterial Management System will comprise a total of approximately 46 centerline miles. These sections of highway are considered the initial group of facilities around which the proposed traveler information database will be designed. Other types of information (other than current volume and congestion values) will likely include transit schedules, road closure and construction and maintenance activities, road closures due to flooding, and general weather advisories. The initial center will be housed at the City of Tucson TMC.

For information dissemination, it is recommended that a cable television server be installed for the two major cable companies within the region. Also, a server which provides access through a bulletin board which can be accessed through home or office PCs will be implemented. An alternative to a PC bulletin board would be an Internet page. Also at the center, an automated traveler advisory information system accessed through telephone service is proposed.

Outside of the center itself, it is recommended that four kiosks be constructed in public buildings or public areas. Each kiosk would provide real time information on the current and future status of the transportation system. The preliminary recommendation on locations for such kiosks are: Tucson International Airport, the governmental center comprising city and county buildings, the Tucson Convention Center, and the University of Arizona campus. Communications for the system will be via leased lines.

Project Tasks

The project phases and associated tasks are listed below.

Stage 1 - Design

Task 1 Prepare system functional design.

Task 2 Assess required information and database software.

Task 3 Assess public kiosk locations and select four sites

Task 4 Develop operational procedures for traveler information center.

Task 4 Assess candidate sites and select location for center.

Stage 2 - System Installation

Task 5 Install hardware and software at traveler information center

Task 6 Install public kiosks

Task 7 Develop information database.

Task 8 Integrate system and acceptance test.

Stage 3 - Project Assessment

Task 9 Perform assessment of system impacts

Project Schedule

The project duration is estimated to be 18 months. However, depending upon the pace of implementation for the Freeway Management System and the Arterial Traffic Management System, the initial amount of information available through the center may be minimal. Only with the Freeway and Arterial Management Systems in place will a significant amount of real time information on selected roadways be made available through the television, computer, kiosk, and telephone elements of the RTIC. Note that significant involvement from the private sector is anticipated, including financial support which may help to reduce total budget costs.

Project Cost

The total cost for designing, installing, and accessing the traveler information center is $0.700 million. A breakdown of this cost is given below.

Stage 1 - Assessment and Design	$50,000
Stage 2 - Implementation	
Traveler Information Database	
(Hardware and Software)	200,000
Cable TV Server	50,000
Bulletin Board Service Server	50,000
Public Kiosks	200,000
Traveler Advisory Telephone System	100,000
Stage 3 - Project Assessment	50,000
TOTAL	$700,000

There are three supplementary activities which need to be carried out in parallel to make the Traveler Information Center operate at an effective level. First, PAG and its member agencies need to develop a detailed plan of responsibility and operations for the overall concept of traveler information. Second, the Freeway Management System and the Arterial Traffic Management System covering four major arterials need to be implemented so that a significant amount of real time traffic flow information can be generated and fed to the Traveler Information Center.

The third supplementary activity will be for the public jurisdictions to generate interest and support from the private sector. Such support would be both financial and non-financial in nature. The private sector, including cable TV stations and major activity centers such as hotel and major employers should be brought in to the ITS Deployment Strategy on an early basis and should remain active partners throughout.

APPENDIX D
ITS PHASING PLAN

ITS System Components	Phase 1 0-5 years	Phase 2 5-10 years	Phase 3 10+ years
Freeway Management System (FMS)	• congestion detection • CCTV Monitoring • Changeable Message Signs	• Expand coverage of FMS • Ramp metering • Commercial vehicle monitoring	• Enhance FMS
Arterial Traffic Management System (ATMS)	• congestion detection • CCTV Monitors	• Expand coverage • Changeable Message Signs • Additional CCTV • Fiber-optic links	• Enhance ATMS • Additional Changeable Message Signs
Transit Management System (TMS)	• Complete Sun Tran/Van Tran management systems	• Upgrade Sun Tran/Van Tran Management Systems	• Continue upgrade
Regional Traveler Information Center (RTIC)	• Cable TV linkages • Internet page • Traveler advisory tetephone • Information kiosks	• Expand Coverage	• Expand privatization • Enhance fiber-optic links

GLOSSARY OF ACRONYMS

ADOT	ARIZONA DEPARTMENT OF TRANSPORTATION
ATIS	AUTOMATED TRAVELER INFORMATION SERVICE
ATM	ASYNCHRONOUS TRANSFER MODE
ATMS	ADVANCED TRAFFIC MANAGEMENT SYSTEM
AVL	AUTOMATIC VEHICLE LOCATION
CAC	CITIZENS ADVISORY COMMITTEE
CAP	COMPETITIVE ACCESS PROVIDERS
CMAQ	CONGESTION MITIGATION AIR QUALITY
CMS	CHANGEABLE MESSAGE SIGNS
CCTV	CLOSED CIRCUIT TELEVISION
EPIC	EXPEDITED CROSSING AT INTERNATIONAL BORDERS
FHWA	FEDERAL HIGHWAY ADMINISTRATION
FMS	FREEWAY MANAGEMENT SYSTEM
GPS	GLOBAL POSITIONING SYSTEMS
HAR	HIGHWAY ADVISORY RADIO
HURF	HIGHWAY USER REVENUE FUND
ISTEA	INTERMODAL SURFACE TRANSPORTATION EFFICIENCY ACT
ITI	INTELLIGENT TRANSPORTATION INFRASTRUCTURE
ISDN	INTEGRATED SERVICES DIGITAL NETWORK
ITS	INTELLIGENT TRANSPORTATION SYSTEMS
IVHS	INTELLIGENT VEHICLE HIGHWAY SYSTEMS
LTAF	LOCAL TRANSPORTATION ASSISTANCE FUND
MMP	MOBILITY MANAGEMENT PLAN
NAFTA	NORTH AMERICAN FREE TRADE AGREEMENT
NHS	NATIONAL HIGHWAY SYSTEM
PAG	PIMA ASSOCIATION OF GOVERNMENTS
PAGTPD	PIMA ASSOCIATION OF GOVERNMENTS TRANSPORTATION PLANNING DIVISION
PS&E	PLANS, SPECIFICATIONS AND ESTIMATES
PSA	PUBLIC SERVICE ANNOUNCEMENT
RBDS	RADIO BROADCAST DATA SERVICE
RF	RADIO FREQUENCY
RFP	REQUEST FOR PROPOSALS

RHODES	REAL-TIME HIERARCHICAL OPTIMIZED DISTRIBUTED EFFECTIVE SYSTEM
RTIC	REGIONAL TRAVELER INFORMATION CENTER
SAC	STUDY ADVISORY COMMITTEE
SDP	STRATEGIC DEPLOYMENT PLAN
SONET	SYNCHRONOUS OPTICAL NETWORK
STIP	STATE TRANSPORTATION IMPROVEMENT PROGRAM
STP	SURFACE TRANSPORTATION PROGRAM
TAC	TECHNICAL ADVISORY COMMITTEE
TATTIP	TUCSON ADVANCED TRANSPORTATION TECHNOLOGIES IMPLEMENTATION PLAN
TCM	TRAFFIC CONTROL MEASURES
TCOM 2000	TUCSON ADVANCED TECHNOLOGIES COMMUNICATIONS PLAN
TDM	TIME DIVISION MULTIPLEXED
TDM	TRAVEL DEMAND MANAGEMENT
TIP	TRANSPORTATION IMPROVEMENT PROGRAM
TMC	TRAFFIC MANAGEMENT CENTER
TSM	TRANSPORTATION SYSTEMS MANAGEMENT
TOC	TRAFFIC OPERATIONS CENTER
UA	UNIVERSITY OF ARIZONA
U.S. DOT	UNITED STATES DEPARTMENT OF TRANSPORTATION
US/O	USER SERVICES/OPTIONS
WAN	WIDE AREA NETWORK

LIST OF TECHNICAL MEMORANDA

User Services/Options Study

TECHNICAL MEMORANDUM NO. 1	Define User Services Plan Development Process
TECHNICAL MEMORANDUM NO. 2	Assess Regional ITS Resources and Operations
TECHNICAL MEMORANDUM NO. 3	Acquire Public and Stakeholder Input
TECHNICAL MEMORANDUM NO. 4	Document User Service Plan
TECHNICAL MEMORANDUM NO. 5	Establish Performance Criteria and Evaluation Standards
TECHNICAL MEMORANDUM NO. 6	Identify Functional ITS Requirements Define and Evaluate ITS Options

TCOM 2000

TECHNICAL MEMORANDUM NO. 1	Define Infrastructure
TECHNICAL MEMORANDUM NO. 2	Define Communications Requirements
TECHNICAL MEMORANDUM NO. 3	Define Communications Architecture Specify Physical Components